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…Y-FIFTH ANNUAL REPORT

STATE BOARD OF HEALTH

MASSACHUSETTS.

BOSTON:

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THIRTY-FIFTH ANNUAL REPORT

OF THE

STATE BOARD OF HEALTH

OF

MASSACHUSETTS.

BOSTON:
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The State Board of Publication.

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1903-1904.

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Consulting Chemist.
THOMAS M. DROWN, M.D.

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GENERAL REPORT.

The following report comprises the general or routine work of the State Board of Health for the year ended Sept. 30, 1903, together with its operations under the food and drug acts for the same period, and under the acts relating to water supply and sewerage during the calendar year 1903.

The first part, paged in Roman numerals, contains a condensed account of the work done under the laws defining the duties of the Board.

The regular work of the Board is performed mainly under the provisions of three separate acts, — an organic act of 1869, establishing the Board; an act of 1882, providing for the inspection of food and drugs; and an act for the protection of the purity of inland waters, of 1886, together with the amendments of these acts, all of which have been embodied in chapter 75 of the Revised Laws of Massachusetts, enacted in 1901.

The second part of this report, paged in Arabic figures, presents the fuller details of the work of the Board under the acts above referred to.

The following members comprised the Board in 1903: —

HENRY P. WALCOTT, *Chairman*.

HIRAM F. MILLS.	CHARLES H. PORTER.
JAMES W. HULL.	JULIAN A. MEAD.
GERARD C. TOBEY.	JOHN W. BARTOL.

GENERAL HEALTH OF THE STATE IN 1903.

The vital statistics of a given community constitute the most definite index of the general health of such community during any stated year or series of years. Measured upon this plan the health of Massachusetts during 1903 differed but little from that of either of the years immediately preceding (1901 and 1902). The death-rate of these three years was less than that of any year in the last half century and probably less than that of any year in the nineteenth century, since it is known that infectious diseases prevailed throughout the earlier years of the century with far greater virulence than at the present time.

The number of deaths in the State in 1903 was 49,054, which was equivalent to a death-rate of 16.32 per 1,000 upon an estimated population of 3,006,040. This was but slightly greater than that of the previous year, which was 16.17 per 1,000.

The mean death-rate of the three years 1901, 1902 and 1903 was 16.43, which was much less than that of any three successive years since the beginning of registration in 1842.

The following figures are presented for the ten years ended with 1903 : —

Massachusetts.

Years.	Population.*	Deaths.	Death-rates.	Years.	Population.*	Deaths.	Death-rates.
1894, ...	2,445,604	46,791	19.14	1899, ...	2,741,470	47,710	17.40
1895, ...	2,500,183	47,540	19.01	1900, ...	2,805,346	51,156	18.24
1896, ...	2,558,443	49,381	19.30	1901, ...	2,870,710	48,275	16.82
1897, ...	2,618,051	47,419	18.11	1902, ...	2,937,600	47,491	16.17
1898, ...	2,679,049	46,761	17.46	1903, ...	3,006,040	49,054	16.32

* Population estimated for intercensal years.

Infectious Diseases.

The death-rate from the principal infectious diseases in 1903 was generally less than that of the previous year. There was an increase in the number of deaths from scarlet fever, whooping-cough and pneumonia, and a decrease in the deaths from smallpox, diphtheria, typhoid fever, measles, cholera infantum, consumption, dysentery and cerebro-spinal meningitis.

The deaths and death-rates from each of the foregoing diseases and from cancer in the past five years are shown in the following table : —

Deaths and Death-rates from Certain Diseases in Massachusetts, 1899–1903.

	1899.		1900.		1901.		1902.		1903.	
	Deaths.	Death-rates per 10,000.	Deaths.	Death-rates per 10,000.	Deaths.	Death-rates per 10,000.	Deaths.	Death-rates per 10,000.	Deaths.	Death-rates per 10,000.
Smallpox, ...	14	.05	3	.011	97	.34	284	.97	22	.07
Diphtheria and croup, . . .	1,047	3.82	1,475	5.26	1,166	4.06	873	2.97	869	2.89
Scarlet fever, ...	235	.86	391	1.39	385	1.34	313	1.07	510	1.70
Typhoid fever, ...	612	2.23	632	2.25	561	1.95	538	1.83	527	1.75
Measles, ...	241	.88	330	1.18	173	.60	333	1.13	247	.82
Cholera infantum, ...	1,964	7.16	2,393	8.53	2,705	9.43	3,157	10.75	2,469	8.21
Consumption, ...	5,221	19.05	5,199	18.53	5,033	17.54	4,685	15.95	4,531	15.07
Dysentery, ...	268	.98	257	.92	223	.78	193	.66	188	.63
Whooping-cough, ...	338	1.23	337	1.20	210	.73	337	1.15	519	1.73
Pneumonia, ...	4,993	18.21	5,282	18.83	4,772	16.62	4,583	15.60	5,190	17.27
Cancer, ...	1,838	6.70	1,998	7.12	2,080	7.25	2,141	7.29	2,243	7.46
Cerebro-spinal meningitis, . .	240	.88	198	.71	177	.62	165	.56	156	.52

The State has been unusually free from serious epidemics of disease during the past ten years, and especially during the past three years, a condition to which an increasingly efficient municipal sanitary administration has undoubtedly contributed materially.

In the following table a balance is presented between the deaths from the principal infectious diseases in the two years 1902 and 1903, by which it appears that the sum of the deaths from these eleven causes in 1903 was less by 233 than those of 1902 from the same causes.

In the report of 1902 a table and diagram were presented showing the very marked changes which had taken place in the mortality from different causes during the last half century, the combined death-rates from the principal infectious diseases having diminished from 83.2 per 10,000 to 45.5 in that time, while the combined death-rate from the principal local diseases, with pneumonia and cancer, had also increased in the same time from 26.0 per 10,000 to 67.3.

Deaths from Certain Infectious Diseases in 1902 and 1903.

Diseases.	1902.	1903.	Increase.	Decrease.
Smallpox,	284	22	-	262
Diphtheria and croup,	873	869	-	4
Scarlet fever,	313	510	197	-
Typhoid fever,	538	527	-	11
Measles,	333	247	-	86
Cholera infantum,	3,157	2,469	-	688
Consumption,	4,685	4,531	-	154
Dysentery,	193	188	-	5
Whooping-cough,	337	519	182	-
Pneumonia,	4,583	5,190	607	-
Cerebro-spinal meningitis,	165	156	-	9
	15,461	15,228	986	1,219

Infant Mortality.

A prominent contributory factor to the low death-rate of the past three years has been not only the absence of serious epidemics of disease, but also an unusually low rate of infant mortality, that of the three years 1901, 1902 and 1903 combined having been considerably lower than the infant mortality of any three successive years in the last half century.

The highest rate in any year was that of 1872, which attained the excessively high figure of 202.7 per 1,000 births.

For the sake of accuracy the death-rate of infants under one year old is obtained by comparing the deaths of such infants occurring in a year with the mean number of infants under one living throughout a year, and this number must "lie between the annual number of births and that number diminished by the deaths under one. It would be nearer the latter than the former number on account of the excess of deaths in the first months of life" (Dr. Farr). In the following table the births in the first line are

those which occurred between July 1, 1893, and June 30, 1894, inclusive, and so on through the table, the births in the last line being those for the year ended June 30, 1903.

The deaths under one in the same table are those of the calendar years ended Dec. 31, 1894, 1895, etc. The births during these ten years were 712,266 and the deaths under one year were 107,319, which is equivalent to an infant mortality-rate of 150.7 per 1,000 births for the decade. But the last half of the period shows a substantial gain over the first half, since the infantile death-rate in the last five years was 144.7 per 1,000 births, as compared with 156.8 in the first five years.

Infant Mortality, Massachusetts: 1894 1903, Ten Years.

Years.	Births in Year ending June 30.	Deaths under One Year.	Death-rate under One Year per 1,000 Births.	Years.	Births in Year ending June 30.	Deaths under One Year.	Death-rate under One Year per 1,000 Births.
1894, . .	67,574	10,899	161.3	1899, . .	71,156	10,532	148.0
1895, . .	66,746	10,564	158.2	1900, . .	72,430	11,500	159.0
1896, . .	70,167	11,765	167.7	1901, . .	72,559	9,952	137.2
1897, . .	72,578	10,751	148.1	1902, . .	71,770	10,075	140.4
1898, . .	73,868	11,012	149.1	1903, . .	73,618	10,269	139.5

Total births in ten years ended June 30, 1903, 712,266.
Total deaths under one in ten years ended Dec. 31, 1903, 107,319.
Mean infantile death-rate, 150.7 per 1,000 births.

Smallpox.

With the close of the year 1903, the epidemic of smallpox, which began in the spring of 1901, may be considered as having come to an end. When compared with the epidemic of thirty years ago (1871–73) its destructive effect upon the population was comparatively slight, the deaths from this cause in the former epidemic having been 1,991 in the three years 1871–73, while those in the latter period (1901–03) were 400, or scarcely one-fifth as many.

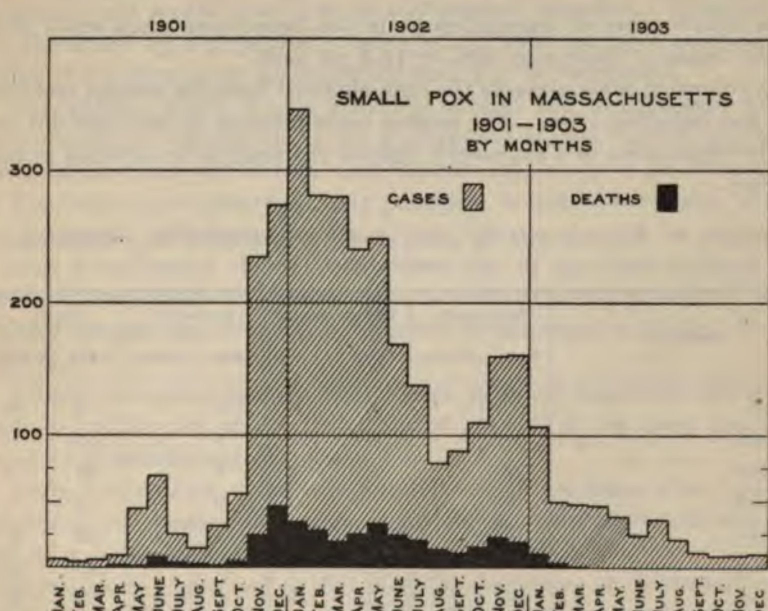
The total number of reported cases which occurred in 1903 was 417 and the deaths of these were 19. Of this number, 194 cases were those of males, with 7 deaths, and 220 were of females, with 8 deaths; and there were 3 cases in which the sex was not stated.

No record was kept of the number of cases which occurred in the State in 1871-73, but owing to the existence of efficient laws requiring the reporting of all cases since 1883, it appears that 3,500 cases had been reported to the State Board of Health in the three years 1901–03, thus making a fatality of 11.4 per cent. The experiences of physicians who had observed both the earlier and the later epidemics appear to show that the latter was much the milder in its effect upon the population. Out of more than 200 cases which were reported between April 1 and Dec. 31, 1903, there were no deaths.

The following table and diagram illustrate the course of the epidemic by months during these three years 1901–03: —

Smallpox by Months, Massachusetts, 1901–1903.

	Cases.	Deaths.		Cases.	Deaths.
1901.			**1902.**		
January,	6	-	July,	138	21
February,	4	-	August,	79	14
March,	6	-	September,	88	12
April,	9	2	October,	110	16
May,	45	1	November,	160	23
June,	70	8	December,	161	20
July,	26	4			
August,	15	3	**1903.**		
September,	32	2	January,	107	11
October,	56	5	February,	50	3
November,	235	25	March,	48	1
December,	274	47	April,	47	-
			May,	39	-
1902.			June,	25	-
January,	347	35	July,	37	-
February,	282	28	August,	22	-
March,	281	20	September,	12	-
April,	241	26	October,	9	-
May,	249	34	November,	10	-
June,	169	25	December,	11	-



The following summary presents the number of reported cases and deaths in each year for the twenty-one years 1883–1903, and shows the exceedingly irregular and epidemic character of the disease, ranging from a minimum of 1 case and no deaths in 1895 to a maximum of 2,305 cases and 274 deaths in 1902.

Summary of Several Years, 1883-1903.

Years.	Cases.	Deaths.	Years.	Cases.	Deaths.
1883, ...	21	5	1894, ...	185	33
1884, ...	9	3	1895, ...	1	-
1885, ...	32	19	1896, ...	5	-
1886, ...	2	-	1897, ...	18	4
1887, ...	13	3	1898, ...	12	-
1888, ...	32	9	1899, ...	105	14
1889, ...	15	6	1900, ...	104	2
1890, ...	6	1	1901, ...	778	101
1891, ...	5	3	1902, ...	2,305	274
1892, ...	19	2	1903, ...	417	19*
1893, ...	45	9	Total, ...	4,129	508

* Four of these deaths, which occurred in the first days of January, 1903, were those of cases reported in December, 1902, and in reckoning the fatality of cases should be classed with the deaths of 1902.

The total number of reported cases in the twenty-one years was 4,129, and the deaths of these were 508, or 12.3 per cent.

The following table presents the data obtained from the returns received since and including 1888. The returns made previous to that date did not contain information of a sufficiently definite character to be included in this summary.

Smallpox in Massachusetts by Ages, and with Reference to Vaccination, 1888-1903.

Periods.	Vaccinated.		Unvaccinated.		Unknown.		Total	
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
0-1 year, ...	5	-	178	45	2	-	185	45
1-5 years, ...	33	-	476	56	4	1	513	57
5-10 years, ...	31	-	259	8	9	-	299	8
10-15 years, ...	46	-	127	4	2	-	175	4
15-20 years, ...	90	3	250	17	6	2	346	22
20-30 years, ...	440	28	562	78	21	5	1,023	111
30-40 years, ...	490	43	275	54	7	1	772	98
40-50 years, ...	306	30	126	32	8	-	440	62
Over 50 years, ...	202	36	63	16	3	1	268	53
Age unknown, ...	11	-	9	4	10	-	30	4
Total, ...	1,654	140	2,325	314	72	10	4,051	464

Vaccination and Revaccination. — In a brief statement upon the subject of vaccination, made before the legislative committee on public health, March 1, 1903, President Eliot said: "If there is any demonstrated proposition in this world it is that people by the million are protected by vaccination, especially against death from smallpox."

So far as smallpox is concerned the practice of vaccination may be considered as one of the first and most important principles of sanitation. The opponents of vaccination are wont to advise isolation and disinfection as the cardinal principles of prevention, rejecting vaccination entirely; but the application of this exclusive method fails and breaks down at the straining point, as was shown at Leicester, Eng., where, in a population of only 180,000, among whom were many unvaccinated children, there were 343 cases of smallpox in 1893, — a number relatively a hundredfold greater than has occurred in the well-vaccinated German population of over fifty million inhabitants during the last ten years, and this among a population peculiarly exposed to infection from neighboring countries where smallpox prevails in consequence of neglect of this important measure.

Vaccination should always be performed with as much care and regard to cleanly and aseptic conditions as any surgical operation. It should also be performed by a physician, since medical men are most competent to judge of its effect upon the individual who is to be vaccinated.

The vaccine which is now generally advised and deemed best for the performance of vaccination is the glycerinized animal vaccine, and this is the product which will be furnished from the laboratory of the Board.

The following summary, already published in previous reports, is herewith repeated, with the added figures for 1903: —

Only 5 vaccinated children under one year of age were attacked with smallpox, and these all survived; while there were 178 attacks of unvaccinated infants under one year old, and of this number 45 died, or 25.3 per cent.

Among vaccinated persons under fifteen years old there were 115 attacks and no deaths; but among unvaccinated persons of the same ages there were 1,040 attacks and 113 deaths.

Among vaccinated adults over fifteen years of age there were 1,528 attacks and 140 deaths; and among unvaccinated persons over fifteen years old there were 1,276 attacks and 197 deaths.

It is also worthy of notice that 474 school children, or children of school ages (five to fifteen years), were attacked, and of this number 386, or more than four-fifths, were unvaccinated. There were only 12 deaths out of this number, since this is the period of life when the power to resist fatal attacks of disease is greatest.

Out of the 1,654 who were recorded as having been vaccinated, it was

stated in the returns that nearly 70 per cent. had been vaccinated in childhood or infancy only; and nearly every one of the deaths of adults recorded as "vaccinated" occurred among this class.

The foregoing figures illustrate the decided saving of life among persons of early ages, the gross neglect of vaccination of school children, and the neglect of revaccination among adults.

In reviewing the facts relating to smallpox for 1903, it also appears that, out of the last 200 persons attacked during the year, 148, or 74 per cent., were unvaccinated French Canadians.

Consumption.

The most notable circumstance in connection with this disease is the steady decline in its incidence upon the population of the State. The total number of deaths from this cause registered in 1903 was 4,531, or less than has been recorded in any year since 1868, while the death-rate from the same cause was less than that of any year of record.

The following figures present the deaths and death-rates by ten-year periods during the last half century: —

Deaths and Death-rates from Consumption in Massachusetts, 1851–1902.

Periods.	Deaths.	Death-rates per 10,000.	Periods.	Deaths.	Death-rates per 10,000.
1851-60,	45,252	39.9	1891-1900,	54,374	21.4
1861-70,	45,918	34.9	1901,	5,083	17.5
1871-80,	54,039	32.7	1902,	4,685	15.9
1881-90,	58,303	29.2	1903,	4,531	15.1

The death-rates from this cause in the different cities in the State present considerable variation, according to the character of the population, its density, social condition and the character of its industries.

The following table presents the death-rates from this cause in each of the cities and towns having a population of more than 10,000 by the census of 1900, during the two five-year periods 1891–95 and 1896–1900. In nearly all of these there appears to have been a decrease in the mortality from this disease when these two five-year periods are considered.

In Boston and in Chelsea there are hospitals and other establishments which receive consumptives from other cities and towns, thus increasing the death-rate from this cause in these two cities.

Death-rates per 10,000 from Consumption in Massachusetts Cities and Towns of More than 10,000 Inhabitants, 1891-95 and 1896-1900, showing General Decrease in Mortality from this Cause, arranged according to their Population in 1900.

	1891-1895.	1896-1900.		1891-1895.	1896-1900.
Boston,	31.9	27.4	Waltham,	25.0	18.6
Worcester,	22.1	21.5	North Adams,	18.4	12.3
Fall River,	20.5	21.0	Everett,	22.0	17.8
Lowell,	24.8	20.7	Pittsfield,	18.4	14.0
Cambridge,	27.4	23.3	Brookline,	16.4	10.3
Lynn,	20.0	19.1	Chicopee,	23.3	21.5
New Bedford,	23.5	18.9	Northampton,	19.8	19.2
Lawrence,	20.4	18.8	Medford,	15.1	12.7
Somerville,	20.9	16.3	Newburyport,	23.5	19.1
Springfield,	20.9	17.6	Marlborough,	24.0	20.3
Holyoke,	22.7	21.5	Woburn,	19.3	20.7
Brockton,	19.0	18.1	Beverly,	19.3	14.2
Haverhill,	23.6	17.7	Clinton,	14.8	15.7
Salem,	19.2	16.2	Hyde Park,	19.0	16.7
Chelsea,	28.6	23.3	Melrose,	17.2	15.7
Malden,	20.6	17.0	Westfield,	17.5	18.3
Newton,	17.1	13.1	Weymouth,	25.4	19.6
Fitchburg,	17.8	13.2	Peabody,	17.8	22.7
Taunton,	22.0	22.9	Leominster,	14.8	14.1
Gloucester,	17.3	14.7	Milford,	28.8	22.4
Quincy,	25.9	18.6	The State,	23.1	19.9

Typhoid Fever.

In previous issues of the report of the State Board of Health a summary has been presented of the death-rates from typhoid fever in the cities of the State, from 1871 to the date of the issue of each report, and the table for the thirty years 1871–1900 is given in the report of 1900, by five-year periods, and it is our intention to repeat this table in 1905 with the added period 1901–05.

The following table presents the deaths and death-rates of these cities from this cause during the three years 1901–03.

Deaths and Death-rates from Typhoid Fever in the Cities of Massachusetts, 1901-03.

Cities.	Deaths from Typhoid Fever.	Death-rates per 10,000.	Cities.	Deaths from Typhoid Fever.	Death-rates per 10,000.	Cities.	Deaths from Typhoid Fever.	Death-rates per 10,000.
New Bedford,	73	3.7	Lowell,	61	2.0	Brockton,	17	1.3
North Adams,	29	3.6	Haverhill,	23	2.0	Fitchburg,	13	1.3
Newburyport,	15	3.5	Fall River,	62	1.8	Quincy,	9	1.2
Salem,	34	3.1	Gloucester,	14	1.8	Medford,	7	1.2
Waltham,	22	3.0	Chicopee,	11	1.8	Cambridge,	32	1.1
Pittsfield,	18	2.7	Beverly,	7	1.6	Northampton,	6	1.0
Lawrence,	51	2.5	Worcester,	60	1.6	Newton,	11	1.0
Chelsea,	26	2.5	Lynn,	33	1.5	Marlborough,	2	0.5
Malden,	26	2.4	Melrose,	6	1.5	Woburn,	1	0.2
Springfield,	45	2.2	Everett,	12	1.5	Total,	1,186	2.0*
Taunton,	22	2.2	Holyoke,	20	1.4			
Boston,	392	2.2	Somerville,	26	1.3			

* Calculated from estimated mean annual population of the foregoing cities for the three years 1901-03 of 1,981,267.

By the foregoing table it appears that the death-rate from this cause during the three years 1901–03 was 2.0 per 10,000. By comparing this rate with the following condensed summary from the report of 1900 it appears that the most decided and continuous improvement is constantly going on.

Death-rates from Typhoid Fever per 10,000, 1871-1903, Massachusetts.

1871–75,	8.2	1891–95,	3.4
1876–80,	4.2	1896–1900,	2.6
1881–85,	4.1	1901–03,	2.0
1886–90,	4.6		

For the entire State the death-rates from this cause in 1901, 1902 and 1903 were, respectively, 1.95, 1.83 and 1.75 per 10,000 inhabitants.

The improvement in this direction appears to have kept pace with the continuous improvement in the quality of public water supplies under constant and careful supervision, so that at the present time a larger number of outbreaks of this disease appears to be due to improper handling and care of milk supplies than is caused by pollution of public water supplies. The highest death-rates from this cause among the cities appear to have

occurred in New Bedford (3.7), North Adams (3.6) and Newburyport (3.5); and the lowest occurred in Northampton (1.0), Newton (1.0), Marlborough (0.5) and Woburn (0.2). Marlborough reported only 2 deaths from this cause, and Woburn only 1 in the three years.

Diphtheria.

Very much has been published during the past eight years or more with reference to the comparative death-rates from diphtheria before and after the introduction of treatment by antitoxin. Between the date of the first appearance of this cause of death in the registration returns of the State and 1895 this disease proved to be one of the most destructive causes of death in its incidence upon the population. There were many years previous to 1895 in which the death-rate from this cause exceeded 10 per 10,000 of the population; but in no year since and including 1895 has this death-rate exceeded 7.1 per 10,000, and the average of the past ten years ending with 1903 was not above 5 per 10,000. In the year of this report (1903) the death-rate had fallen to 2.9 per 10,000. Now, while it cannot be reasonably urged that the use of antitoxin has a material effect upon the prevalence or spread of the disease, it certainly has a decided effect upon its fatality, or ratio of deaths to existing cases, and consequently upon the mortality or death-rate from this cause.

This fact is proven not only by the statistics of all civilized communities, but also by the daily clinical experience of physicians, both in general and in hospital practice throughout the world.

The following table shows the deaths and death-rates from diphtheria by five-year periods from 1876 to 1900 and for the single years 1901, 1902 and 1903: —

Deaths and Death-rates from Diphtheria, Massachusetts, 1876-1903.

Years.	Deaths.	Death-rates.	Years.	Deaths.	Death-rates.
1876-1880, ...	13,676	15.8	1896-1900, ...	6,331	4.7
1881-1885, ...	8,944	9.5	1901, ...	1,166	4.1
1886-1890, ...	8,857	8.4	1902, ...	873	3.0
1891-1895, ...	7,652	6.4	1903, ...	869	2.9

Further and more definite information relative to diphtheria may be found in that portion of the report which relates to the production and distribution of antitoxin.

Other Preventable Diseases.

The group of so-called preventable diseases embraces several other causes of death which are quite distinctive in character in addition to those already

specified. The following table presents the deaths and death-rates from five of these causes, measles, scarlet fever, dysentery, cholera infantum and whooping-cough, for the period of thirty-five years, 1866–1900, and for the three years 1901, 1902 and 1903.

Deaths and Death-rates in Massachusetts per 10,000 Living from Certain Infectious Diseases by Five-year Periods, 1866–1900, and for 1901–03.

	Measles.		Scarlet Fever.		Dysentery.		Cholera Infantum.		Whooping-cough.	
	Deaths.	Death-rates.	Deaths.	Death-rates.	Deaths.	Death-rates.	Deaths.	Death-rates.	Deaths.	Death-rates.
1866-70, . .	1,081	1.6	4,670	6.8	3,244	4.7	6,943	10.1	1,481	2.1
1871-75, . .	1,133	1.4	6,782	8.6	2,191	2.8	12,453	15.8	1,561	2.0
1876–80, . .	742	0.9	3,517	4.1	2,366	2.7	9,054	10.5	1,493	1.7
1881-85, . .	1,007	1.1	2,504	2.7	1,601	1.7	9,894	10.5	1,218	1.3
1886-90, . .	1,089	1.0	1,810	1.7	1,276	1.2	10,904	10.3	1,421	1.3
1891-95, . .	815	0.7	2,857	2.4	1,083	0.9	13,426	11.2	1,445	1.2
1896-1900, . .	948	0.7	1,358	1.0	1,434	1.1	11,865	8.9	1,465	1.1
1901, . . .	173	0.6	385	1.3	223	0.8	2,705	9.4	210	0.7
1902, . . .	333	1.1	318	1.1	193	0.7	3,157	10.7	337	1.1
1903, . . .	247	0.8	510	1.7	188	0.6	2,469	8.2	519	1.7

The deaths from cerebro-spinal meningitis were 156, which was less than those of any year since 1896 from the same cause, and represented a death-rate of 0.5 per 10,000 living.

There were two deaths from glanders during the year and none from hydrophobia.

Health Legislation enacted at the Legislative Session of 1904.

During the legislative session of 1904 very many bills were introduced pertaining to sanitary questions and allied topics, but the following act is the only general statute pertaining to the public health which was finally enacted. The emergency which gave rise to this legislation was the discovery of a case of leprosy in the town of Harwich.

[Chapter 395 of the Acts of 1904.]

An Act relative to the care of persons infected with diseases dangerous to the public health.

Section 1. The state board of charity may, if found expedient, remove any person who is infected with a disease dangerous to the public health, and who is maintained or liable to be maintained by the Commonwealth, to any hospital provided for state paupers, or may provide such place of reception for such person as is judged best for his accommodation and the safety of the public, which place

shall be subject to the regulations of the board, and may remove such person thereto.

SECTION 2. Any expenses incurred in carrying out the provisions of this act may be paid from the annual appropriation for expenses in connection with smallpox and other diseases dangerous to the public health.

The following special act requires the approval by the State Board of Health, together with certain other authorities, of the plans for the construction of a dam across the Mystic River in Medford, and also directs the Board to report to the next General Court "a method and plans for purifying the Mystic River, Alewife Brook, and the adjacent water courses, ponds and drainage areas."

[CHAPTER 445 OF THE ACTS OF 1904.]

AN ACT TO AUTHORIZE THE CONSTRUCTION OF A DAM ACROSS THE MYSTIC RIVER AT CRADOCK BRIDGE IN THE CITY OF MEDFORD AND TO PROVIDE FOR A REPORT ON THE PURIFICATION OF MYSTIC RIVER, ALEWIFE BROOK, AND THE ADJACENT WATER COURSES, PONDS AND DRAINAGE AREAS.

SECTION 1. The metropolitan park commission is hereby authorized to build, maintain and care for a dam across Mystic river at or near Cradock bridge in the city of Medford, with suitable gates, sluices and machinery for operating the same and with weirs, rollways, locks and other apparatus and devices for passing over and around the dam: *provided, however*, that the plans therefor shall first be approved by the board of harbor and land commissioners, and by the United States government, and by the state board of health as to the plans being consistent with the improvement and purification of Mystic river and Alewife brook.

SECTION 2. The state board of health is hereby directed to prepare and report to the next general court a method and plans for purifying Mystic river, Alewife brook and the adjacent water courses, ponds and drainage areas, with due regard to the purposes indicated in chapter three hundred and twenty-seven of the acts of the year nineteen hundred and three and to the plans of the metropolitan park commission for park developments within the said region, and in conference with the commission appointed under said chapter. For these purposes said board may employ such clerical, engineering and other assistance, and may print such copies of its report and plans as it may deem necessary. The expense incurred hereunder shall be divided and paid one half by the metropolitan park commission and one half by the cities and towns named in said chapter three hundred and twenty-seven as an expense incurred under said act.

The following resolves, also enacted in 1904, provide for certain investigations to be made by the State Board of Health: —

[CHAPTER 27 OF THE RESOLVES OF 1904.]

RESOLVE TO PROVIDE FOR AN INVESTIGATION BY THE STATE BOARD OF HEALTH AS TO THE BUSINESS OF UNDERTAKING AND EMBALMING.

Resolved, That the state board of health is hereby requested to investigate the necessity or desirability of legislation to regulate the business of undertaking

and embalming, and to report the result of such investigation, with the recommendations of the board, to the general court on or before the first Wednesday of May in the year nineteen hundred and four.

[CHAPTER 99 OF THE RESOLVES OF 1904.]

RESOLVE TO PROVIDE FOR AN INVESTIGATION AS TO SANITARY AND OTHER CONDITIONS AFFECTING THE HEALTH OR SAFETY OF EMPLOYEES IN FACTORIES AND OTHER ESTABLISHMENTS.

Resolved, That the state board of health, with such aid as it may require from the chief of the district police and the bureau of statistics of labor, is hereby directed to investigate the sanitary conditions of factories, workshops and other places of employment in the Commonwealth of Massachusetts, with respect to all conditions which may endanger the life and limb or be prejudicial to the health of the persons employed therein. The officers and employees of said board shall have power to enter and inspect all premises in use for industrial purposes and to obtain such information as may be necessary for carrying out the purposes of this resolve. The board may expend a sum not exceeding one thousand dollars in carrying out the provisions of this resolve, and is directed to report to the next general court on or before the fifteenth day of January next, and shall accompany its report with such recommendations as it deems advisable.

WATER SUPPLY AND SEWERAGE.

In the year 1903 the Board has received 129 applications for advice with reference to water and ice supply, sewerage and the prevention of the pollution of streams, — 36 more than in the previous year. The action of the Board in response to these applications is given on pages 5 to 134 of this report.

Water Supplies.

Public water supplies were introduced during the year in the towns of Deerfield, Shirley and Williamsburg; and at the end of the year 171 cities and towns, containing about 92 per cent. of the total population of the State, were provided with public water supplies. In the case of the larger cities and towns the public supply is available to practically the entire population, but in the smaller places there is in most cases a large rural population to which the public water supply is not available, so that the population actually supplied from public works is somewhat less than the percentage indicated. All of the cities and towns of the State having a population, according to the census of 1900, in excess of 3,500, are now provided with public water supplies, excepting the towns of Barnstable, Blackstone, Chelmsford, Dartmouth, Dudley, Pepperell and Tewksbury.

The waters of 230 sources of public water supply have been examined at intervals during the year by means of chemical analyses, and the waters of many of the surface sources have also been analyzed microscopically. Bacterial examinations have been made of the waters of many of the wells and filter galleries used as sources of public water supply.

Rules and Regulations for preventing the Pollution and securing the Sanitary Protection of Waters used as Sources of Public Water Supply. — In response to petitions from the authorities of the cities of Fitchburg, Pittsfield and Fall River, and the towns of Attleborough, Weymouth, Lincoln and Peabody, the Board has established rules and regulations for preventing the pollution and securing the sanitary protection of ponds and streams used by those municipalities as sources of public water supply. These rules and regulations are similar to those which have been adopted by the Board in previous years for the protection of the waters used by the metropolitan water supply district and by Cambridge, Salem, Marlborough, Norwood, Danvers, Haverhill, Rockport and Taunton.

A copy of the rules and regulations adopted for the protection of the waters of North Watuppa Lake, used as a source of water supply for the city of Fall River, is given on page 22 of this volume. The enforcement of these rules and regulations rests in all cases with the local authorities, since no appropriation has been made to enable this Board to carry out their provisions.

A petition from the authorities of the city of Lynn, requesting the Board to adopt rules and regulations for the sanitary protection of the sources of water supply of that city was received by the Board and the matter investigated during the year. The sources of water supply of the city of Lynn are a series of ponds, known as Breed's, Birch, Glen Lewis, Walden and Hawkes ponds, and the Saugus River above Montrose, from which there is a conduit leading to Hawkes Pond, having a capacity for delivering about 30,000,000 gallons per day. The water-shed of the Saugus River above the point at which water is taken for the use of the city of Lynn was found, upon examination, to contain a population of nearly 800 persons per square mile of water-shed, and chemical analyses of the water of the streams flowing from the densely populated parts of this water-shed show that they are being badly polluted. Under these circumstances the Board deemed it impracticable to protect the sources of water supply used by the city of Lynn from sewage pollution by any rules and regulations that it is practicable to enforce, and so notified the city; and at the same time advised the city authorities that the use of the Saugus River as a source of water supply, under the existing conditions, constitutes a great danger to the health of the inhabitants of the city, and recommended that the use of this source in its present condition be discontinued.

There has been a great increase in the use of lakes and ponds as summer resorts in recent years. The number of summer cottages and camps about the various lakes and ponds in the State has increased rapidly, and the aggregate population present in the neighborhood of some ponds in summer is very large. It is essential, for the protection of the health of those who use the water of lakes and ponds for drinking, that danger of pollution of

the water be prevented. The difficulty of preventing pollution increases rapidly with the number of people living within the water-shed of the source, and it is especially difficult to prevent pollution where large numbers of people live upon the shores of the source itself, or use it as a pleasure resort. For these reasons the use of a source of domestic water supply as a pleasure resort should be prevented. Their use as sources of ice supply may not, in some cases, be incompatible with the use of the water for domestic purposes, depending upon the care exercised to prevent danger of pollution of the water in the harvesting of the ice.

Sewerage and Sewage Disposal.

Plans were approved by the Board during the year for the construction of systems of sewerage and sewage disposal in the cities of Salem, Fitchburg and Northampton, and in the towns of Easthampton and Hudson, under the provisions of special acts of the Legislature relating to the construction of sewerage and sewage disposal systems in these places. Many plans of sewage disposal systems presented under the general law have also been considered by the Board during the year.

In the examination of sewer outlets and the effect of sewage disposal the work done during the year has been confined to an examination of the sewage disposal systems and the results are presented in detail in a subsequent portion of this volume.

The sewage purification systems of the State were built and are operated for the purpose of preventing the pollution of streams by sewage. In many important cases this result is not at present being attained. The chief reason for this is the inadequacy of the existing disposal works. In most of the places where such works are in existence the works first constructed were of ample size for the requirements of the town when the operation of the system was first begun, but in many cases little or no provision has been made for the growth of the town and the increase in the quantity of sewage. In some other cases the improper construction of sewers, resulting in an excessive leakage of ground water into them, or the use of the sewers for the removal of surface water, has resulted in the discharge of an excessive quantity of sewage at the disposal works at certain times which the works are incapable of purifying properly. In a few cases in which the sewage has to be pumped, expense in pumping is saved at times when the flow of sewage is large, especially in the winter and spring, when the stream flow is also large, by allowing a portion of the sewage to flow untreated into a convenient water course.

In the examinations made during the past year it has been found that large quantities of sewage are discharged into neighboring streams at Gardner, Lenox, Marlborough, Natick and Southbridge. Sewage is also

discharged into the streams at Andover, Hopedale and Pittsfield, and occasionally at Clinton, Brockton and Spencer.

At Gardner, about half of the sewage of the town is discharged upon a filtration area in Gardner, which has now been in operation for a period of more than twelve years; while the sewage of nearly all of the remainder of the thickly settled portion of the town is discharged upon an area in the town of Templeton which was completed about two years ago. The sewage conveyed to the Templeton area is all well purified before being discharged into the stream; but the quantity of sewage conveyed to the older filtration area is greatly in excess of the capacity of the filters for properly purifying the sewage, and during much of the year a large portion of the sewage is discharged untreated into Town Brook. The plans of sewerage of the town provide for the removal of a part or all of the sewage from the older area to the new filtration area in Templeton, which can easily be made ample for the purification of all of the sewage of the town.

At Lenox, where purification works have nominally been used for several years, it was found during the past year that the greater portion of the sewage, even in the summer season, was being discharged in an unpurified state directly into the Housatonic River close to the Lenox station, through a submerged pipe discharging at a considerable distance from the bank of the stream. The Board has brought this fact to the attention of the Lenox authorities.

At Marlborough the filtration area has now been in use for twelve years, and, although the area of the filter beds has been increased somewhat, it is inadequate for the purification of all of the sewage conveyed to the filter beds during a large portion of the year. There is an excessive flow in the Marlborough sewers at times of wet weather, due evidently in part to leakage of ground water into the sewers, and probably also to the discharge of surface water into the sewers.

The quantity of sewage discharged at the Natick filtration area was greater during a portion of the year than the filter beds were capable of receiving and purifying, and an outlet was constructed by which sewage was discharged from the filter beds into a swamp, through which it found its way to Bannister Brook. The filter beds are inadequate for the purification of all of the sewage now brought to them from the town of Natick, and, moreover, the beds are not operated in such a manner as to secure the highest degree of efficiency. A much larger area of filter beds is necessary.

At the Framingham filtration area, adjacent to the Natick area, the filter beds are well cared for, the sewage thoroughly purified, and no unpurified sewage appears ever to have been discharged from these works since they were first operated fourteen years ago.

At Southbridge the filtration area is probably of sufficient size, for the

present at least, to purify adequately all of the sewage now brought there by the sewers of the town; but the filtration area does not receive proper care, and during much of the time in the past year the sewage has flowed over a few of the beds and found its way through an opening in one of the embankments directly into the river.

At Andover the sewage of the greater portion of the town is collected into a main sewer and conveyed to the filtration area by gravity, and all the sewage brought to the filtration area is well purified before being discharged into the Shawsheen River. A portion of the main village of Andover is situated below the level of the main sewer, and the plans of sewerage for the town approved by this Board provided for pumping the sewage of these areas, when sewers should be constructed, into the main sewer. Sewers have been constructed and pumps for this purpose installed; but during much of the time in the past year the pumps have not been operated, and the sewage has been discharged directly into the Shawsheen River.

At Hopedale the plans of sewerage and sewage disposal of the town provided for collecting the sewage in a large tank, from which it was to be pumped to a filtration area and purified by intermittent filtration. The tank in which the sewage is collected has been operated as a septic tank, and became practically filled with solid matter in the early part of the year. At several examinations of these works it was found that the pumps were not running, and all of the sewage was flowing directly into the Mill River.

At Pittsfield works for the purification of the sewage were constructed in the year 1902, and have been operated during the past year. Owing to trouble with the pumps in the beginning, sewage was occasionally discharged into the river at the pumping station. The works, as at present constructed, do not include all of the sewage of the city, there being one large sewer outlet into the west branch of the Housatonic River which has not yet been connected with the system.

At Clinton the sewage is received into a reservoir, from which it is pumped to the filtration area. There is an excessive flow of sewage at certain seasons of the year, owing to leakage of ground water, and possibly also surface water, into the town sewers; and at such times the pumps are run only in the daytime, and the reservoir, often becoming full soon after the pumps stop running in the evening, is allowed to overflow directly into the south branch of the Nashua River near its mouth. This overflow occurs usually at a time of high flow in the river, but the discharge of any sewage into the river could be prevented by running the pumps for a longer period at such times.

At Brockton sewage is occasionally allowed to overflow from the collecting reservoir at the pumping station into the Salisbury Plain River, when the flow of sewage is increased greatly by leakage of ground water into the sewers.

At Spencer the sewage of the town is conveyed by gravity to a filtration area lying at a much lower level, where ample provision has been made for the purification of all of the sewage. Upon the main sewer between the town and the filtration area there is a depression in the main pipe, or an inverted siphon, so called, and at the upper end of this siphon a screen has been placed, with a view to preventing clogging of the siphon, and above this screen is an overflow into the Seven Mile River. It appears, from the examinations made during the past year, that sewage is occasionally diverted into the river; and it has also been found that overflows occur frequently, from the partial clogging of the screens, which require frequent cleaning. The discharge of any crude sewage into the river is unnecessary, since the works are of ample capacity for purifying all of the sewage.

The Neponset River.

By the provisions of section 1 of chapter 541 of the Acts of the year 1902 the State Board of Health is "authorized and directed to prohibit the entrance or discharge of sewage into any part of the Neponset river or its tributaries, and to prevent the entrance or discharge therein of every other substance which may be injurious to public health or may tend to create a public nuisance or to obstruct the flow of water, including all waste or refuse from any factory or other establishment where persons are employed, unless the owner thereof shall use the best practicable and reasonably available means to render such waste or refuse harmless."

Under the provisions of this act the State Board of Health has made an examination to determine the sources of pollution of the Neponset River, and in the latter part of the summer issued the following notice to those cities, towns and persons who were found to be discharging sewage or other polluting substances into the river and its tributaries: —

In accordance with the provisions of chapter 541 of the Acts of the year 1902, all persons and corporations are hereby prohibited from discharging or permitting the entrance of sewage into any part of the Neponset River or its tributaries, and from discharging or permitting the entrance therein of every other substance which may be injurious to public health, or may tend to create a public nuisance, or to obstruct the flow of water, including all waste or refuse from any factory or other establishment where persons are employed, unless the owner thereof shall use the best practicable and reasonably available means to render such waste or refuse harmless.

Under the provisions of the act referred to the Board is directed to consult with and advise owners of factories or other establishments where persons are employed, discharging waste or refuse into the stream, as to the best practicable and reasonably available means of rendering such waste or refuse harmless.

Examinations of Shell-fish.

Investigations as to the condition of shell-fish in waters or flats polluted by sewage have been carried on during the year, special attention being given to methods for the detection of the pollution of shell-fish by sewage. These experiments have included studies to determine whether sewage bacteria are normal and usual inhabitants of shell-fish; how soon after the entrance of sewage bacteria in the water the shell-fish may be affected; the length of time sewage bacteria live in ordinary sea water; the length of time sewage bacteria remain alive in the intestines of shell-fish; the portion of the shell-fish most certain to give a true index of the presence or absence of sewage bacteria, etc.

Experiments carried on during the present year have related especially to clams, but further experiments upon oysters, quahaugs and other shell-fish are now in progress.

Experiments upon the Purification of Sewage and Water at the Lawrence Experiment Station.

The investigations upon the purification of sewage and water at the Lawrence Experiment Station have been carried on as in previous years.

The intermittent sand filters constructed at the beginning of these experiments have now been in operation for sixteen years. In the earlier years some of the surface sand was removed and replaced with clean sand from time to time; but in the last ten years no change has been made in any of the material, and there is no indication that these filters will not continue to purify sewage indefinitely at the rates which have thus far been maintained.

For many years the investigations upon the purification of sewage at Lawrence have been directed especially to methods of increasing the rate of filtration. Experiments upon methods of removing and disposing of suspended matter in sewage and the subsequent purification of the sewage by filtration have been carried on during the year, the principal methods of preliminary treatment under investigation being sedimentation, straining through coarse material, such as coke, cinders, broken stone, etc., and the septic tank. In the studies of the operation of the septic tank much attention has been given to the determination of the cause of the very offensive odor resulting in many cases from this form of preliminary treatment of sewage. Investigations upon the operation of contact and intermittent continuous filters, so called, which are operated at much higher rates than ordinary intermittent filters, have been continued to determine the practicability of the use of these methods under the conditions prevailing in this State. In connection with these experiments many chemical and bacterial analyses have been made at the station, and the results tabulated as in previous years.

Experiments upon the purification of certain manufacturing wastes which contribute greatly to the pollution of streams have also been carried on at the station during the year.

The experiments upon the purification of water have been continued, and during the year experiments have been made with filters operated at very rapid rates, employing sulphate of aluminum as a coagulant.

The usual chemical and bacterial analyses have been made of the water supplied to the city of Lawrence after filtration through the Lawrence city filter.

Food and Drug Inspection.

The work of the State Board of Health in the inspection of food and drugs during the year ended Sept. 30, 1903, will be found reported upon pages 457–526. This work was entrusted to the State Board of Health by a statute enacted in 1882 (chapter 263 of the Acts of that year), and has been conducted continuously under the supervision of the Board since that year.

A brief description of the method of operations conducted under the provisions of this act may be found in the present report. Primarily the work is conducted as a system of inspection, the samples obtained for analysis being purchased in open market in the same manner as such articles are commonly purchased by the consumers. Provision is also made for the examination of articles of food or drugs under proper conditions, which are brought to the office for examination by citizens. This, however, does not include the examination of products intended for sale by dealers or manufacturers or producers, when such examination may be used for advertising purposes. Such examinations should be made by a private chemist.

The number of samples of food and drugs examined by the analysts of the Board during the year ended Sept. 30, 1903, was 10,396, the total number for the whole period of work since 1883 being 148,705.

The number of prosecutions during the year were 79, and the whole number for the whole period of work was 1,726. The detailed account of the prosecutions was sent to the Legislature in January, 1904, and is also published in this report.

The law enacted in 1902, chapter 272, requiring the Board to publish the results of analysis of certain kinds of food products which are found to be adulterated, together with brands and names of manufacturers, has proved a valuable statute and has accomplished much in ridding the State of many adulterated articles where it has been found difficult to deal with them under previous statutes.

During the earlier years under the operations of the food and drug acts, the statutes required that all poisons, when sold, should bear a label notifying the purchaser of this fact, and under the provisions of these statutes

it was possible to secure protection of the people from the danger of using poisonous proprietary preparations, such as cosmetics containing violent poisons and preparations of cocaine, morphia and other alkaloids, the habitual use of which subjects the user to serious danger.

By a later act this statute was so amended as to exempt proprietary medicines from the action of the law, and the sale of such articles of all kinds, whether harmful or not, now continues without any legal power to prevent it.

All recent attempts at legislation to protect the community in this direction have failed, and it is desirable that such protection as formerly existed may be enacted for the public good.

At the session of the Legislature of 1903 a bill was presented having for its object the regulation of the sale of some of the most objectionable of these articles, and the subject was referred to the Board by a legislative order of March 2.

The Board replied to this order, as follows: —

STATE BOARD OF HEALTH.
STATE HOUSE, BOSTON, March 27, 1903.

To the Honorable Senate and House of Representatives.

The State Board of Health respectfully submits the following report in reply to an order received March 2, 1903, requesting the Board to report "as soon as possible whether, in the opinion of the Board, there is anything dangerous to public health in the sale and use of articles commonly known as face bleaches, and if so, what, in the opinion of the Board, is necessary in the way of legislation to protect the public against the sale of said substances."

The Board, in response to the foregoing order, has obtained samples of such cosmetics as are commonly known as face bleaches and had them submitted to analysis, with the following results: —

Nine samples of face bleaches purchased during the present month have been examined. Three of these, viz., Mme. Ruppert's Face Bleach, Soule's Moth, Tan, Freckle and Pimple Eradicator, and Mrs. McCorrison's Diamond Lotion, were strong solutions of corrosive sublimate. None of the bottles contained poison labels, and two of them, viz., Mme. Ruppert's and Mrs. McCorrison's are labelled "harmless."

One sample, viz., Gourand's Oriental Cream, contains calomel; another, Champlin's Liquid Pearl, contains an insoluble lead compound.

The four remaining preparations were mixtures of such ingredients as alcohol, glycerine, bay rum, chalk, sulphur, sulphate of calcium, citric acid, etc.

Instances of harm from the free external use of cosmetics containing corrosive sublimate and lead have come to the knowledge of the Board, and the unrestricted sale of preparations of this character containing active poisons should not be permitted.

The Board would therefore suggest that the law relating to the sale of poisonous proprietary medicines which was in force prior to 1896, requiring a poison

label to be affixed to such articles, would, if re-enacted, provide a greater degree of protection than is possible under existing statutes.

Respectfully yours,

SAML. W. ABBOTT,
Secretary of State Board of Health.

The Inspection of Liquors. — By an act of Legislature, chapter 110 of the Acts of 1902, the powers and duties hitherto exercised by the Inspector and Assayer of Liquors were transferred to the State Board of Health.

These powers and duties, as defined in the earlier statutes (Revised Laws, chapter 100, section 67), required the Inspector of Liquors "to inspect and analyze all liquors sent to him by the licensing board of any city, the selectmen of any town, or by the police or other officers who are authorized by law to make seizure of liquors."

Acting under the new statute of 1902 the Board issued the following circular to the authorities named in the act, and has conducted this work as provided in the act: —

Commonwealth of Massachusetts.

STATE BOARD OF HEALTH.

CIRCULAR RELATING TO INSPECTION OF LIQUORS.

BOSTON, MASS., March 1, 1902.

The attention of selectmen and others is called to chapter 110, Acts of 1902, in accordance with which the powers hitherto exercised by the Inspector and Assayer of Liquors have been transferred to the State Board of Health. Your attention is called to the following points: —

All packages sent by express must be sealed and prepaid. They should be addressed to the analyst of the State Board of Health, Room 501, State House, Boston. Each sample must be accompanied by a certificate, as required by chapter 100 of the Revised Laws, and must bear a mark or label corresponding with the certificate.* It is much better to send an officer with the sample than to send by express. Beer should be in pint or other round beer bottles. Flat flasks frequently burst in warm weather.

Beer kept in a warm place often ferments, thus increasing the amount of alcohol. The question is frequently asked in court, "How long after seizure has this been kept?" To meet this point due diligence should be used in forwarding the sample. All beer, if possible, should be forwarded the day it is seized.

Liquors sent under sections 46 and 67 of chapter 100 of the Revised Laws must be sealed and accompanied by an order from the proper authorities, as named in section 67.

All analyses of liquors are made without expense to the town or city requesting such examinations.

* These certificates can be obtained on application to the Secretary of the Commonwealth.

Directions for taking Samples for Analyses.

The officer making a seizure, or taking samples of beer, should note at the time of such seizure the general appearance of the liquor, — as to whether it is clear or cloudy, whether it is still or has a strong head.

If the liquor is in bottles, take at least one pint bottle; if in barrels, draw a pint bottle from each. Request the owner to seal each sample taken. If the bottles have cork stoppers, cut the stoppers off level with the top of the bottle and cover with wax; if with patent stoppers, a little wax placed upon the wire at the point where it lays against the neck of the bottle is sufficient. If the owner refuses to seal it, then the officer should seal it in his presence, calling his attention to the fact. Before leaving the premises place upon the bottle a label or tag, with the date, the name of the owner, and the name of the officer upon it, and also the name of the town or city. Then place in a box, with the certificate required by law, and forward without delay to the analyst.

FORM OF LABEL.

Town______________________________________

Date of seizure______________________________19

Owner______________________________________

Kind of liquor________________________________

Brewer______________________________________

THE DUMPING OF GARBAGE AND RUBBISH IN THE HARBORS AND ALONG THE SEA COAST OF MASSACHUSETTS BAY.

The State Board of Health, acting under the provisions of chapter 358 of the Acts of 1903, entitled "An Act to direct the State Board of Health to investigate the dumping of garbage and rubbish in the harbors and along the sea coast of Massachusetts Bay, and to report as to the same," made investigations and submitted the following report to the Legislature, March 9, 1904 (Senate, No. 277, session of 1904): —

BOSTON, MASS., March 3, 1904.

To the General Court of Massachusetts.

In conformity with chapter 358 of the Acts of the year 1903, the State Board of Health reports upon the dumping of garbage and rubbish in the harbors and along the sea coast of Massachusetts Bay.

The details in regard to dumping garbage and rubbish into the harbors and into the sea beyond for several years, together with the observations made under the direction of the Board during the past six months, are included in the accompanying report of the chief engineer of the Board.

These observations do not include the conditions in March, April and May, when the strong easterly winds prevail; but, from such observations as we have been able to make since the passage of the act, we conclude that the regulations of the street department of the city of Boston, if carried out, would probably remove at all times the trouble that now exists from such dumping. The objectionable conditions that formerly existed have, to a great extent, been removed by the establishment by the city of Boston in 1899 of garbage-disposal works and of refuse-disposal works, so that there appears to have been very little trouble caused by the dumping of garbage and rubbish into the harbor or along the shores in the vicinity of Boston within the past two or three years.

The most objectionable putrescible matter now discharged into the harbor which is likely to float back to the shore is the refuse from the markets, which is still carried to sea. Much of this material disintegrates slowly and is liable to be carried long distances, and is very offensive when cast up upon the shores. In the classification of the various city wastes this matter would be classed with the garbage, and should be disposed of in connection with that portion of the city waste. It is probable, however, that even this material would not return if it was always carried to the dumping grounds indicated on the chart. The other putrescible matters, such as those from the deposit sewers, from catch-basins and from the cleaning of streets, probably quickly mingle with the water and sink to the bottom, or are thoroughly dispersed before reaching any shore. It is evident from our observations, however, that the scows are often dumped short of the area indicated on the chart, and the garbage from the town of Hull is nearly always discharged much nearer Nantasket beach than the refuse from the city of Boston. With suitable inspection, to see that the refuse and garbage scows which dump material in the harbor always carry their loads to the points indicated by the regulations of the street department of the city of Boston, little or no objection would ever arise from this method of disposing of these wastes.

We present a chart showing the results of the harbor examinations. It will be seen that the dumping boat from the city of Lynn discharges its load very close to Nahant. The Board would advise that the city of Lynn dump its garbage east of the line from Egg Rock to Minot's Light, and at least four miles south-easterly from Eastern Point, Nahant; that the town of Hull dump its garbage in the area designated by the city of Boston, and shown upon the accompanying chart; and that the inspection of all dumping of material off the shores of Massachusetts Bay be put in charge of the Harbor and Land Commission.

The Board would further advise that the inspection of the Harbor and Land Commission include also the dumps upon land on the harbors and along the shores of Massachusetts Bay, to the extent of preventing the dumping of garbage and rubbish in such localities that it can be distributed by the water beyond the limits of the dumping ground.

Manual of Health Laws.

This compilation of the Laws relating to Public Health is now sanctioned as a legal publication by the enactment of chapter 230 of the Acts of 1902, which provides for its publication "not oftener than once in three years." The first edition under authority of this statute was completed and distributed to the local boards of health, and to others who are interested in sanitary matters, in November, 1903.

It embraces all the health legislation in force, including that of the legislative session of 1903.

That portion of the Manual which contains the acts relating to the sale and inspection of food and drugs, together with the decisions of the supreme court upon cases decided before that tribunal, has been published separately for the convenience of parties who desire information upon this subject only.

Copies of the Manual or of the edition of food and drug statutes may be had by application to the secretary, 142 State House, Boston.

Routine Work of the Board.

Statistical Table for the Year ended Sept. 30, 1903.

Whole number of samples of food and drugs examined during the year,	10,396
Samples of milk examined (included in the foregoing),	6,188
Whole number of samples of food and drugs examined since beginning of work in 1883,	148,705
Whole number of samples of milk examined since beginning of work in 1883,	82,307
Number of prosecutions against offenders during the year,	79
Number of convictions during the year,	70
Amount of fines imposed during the year,	$1,297 66
Number of packages of antitoxin of 1,500 units each issued to cities and towns,*	41,133
Number of bacterial cultures made for the diagnosis of diphtheria in cities and towns,*	3,632
Number of examinations made for diagnosis of tuberculosis,*	1,006
Number of examinations of blood made for diagnosis of malarial infection,*	32
Number of examinations of blood made for the diagnosis of typhoid fever,	226
Number of notices of cases of infectious diseases received and recorded under the provisions of chapter 75, section 52, Revised Laws,	25,572
Number of postal-card returns of mortality for cities and towns received and recorded,† about	2,000
Number of annual reports of cities and towns received under the provisions of chapter 75, section 12, Revised Laws,‡	92

Force employed in general work of Board at central office, State House: —	
Secretary,	1
Medical inspector,	1
Clerks,	3
Total,	5

* For the year ended March 31, 1904. † For the calendar year 1903.

‡ Cities and towns having a population of more than 5,000 in each.

Force employed at central office, State House, Boston, for food and drug inspection, chemists and assistants,	2
At Amherst,	1
Inspectors,	4
Total,	7

Force employed at laboratory (Bussey Institution): —	
Pathologist,	1
Assistants,	6
Total,	7

UNDER THE PROVISIONS OF CHAPTER 375, ACTS OF 1888.

Applications for advice from cities, towns and others: —	
Relating to water supply,	78
Relating to ice supply,	11
Relating to sewerage and drainage,	22
Relating to pollution of streams,	11
Miscellaneous,	7
Total,	129

Number of samples of water examined chemically and microscopically at the laboratory, Room 502, State House,	3,613
Number of samples of sewage and effluent from sewage purification works examined chemically at the laboratory, Room 502, State House,	1,297
Number of samples of sewage, water and ice examined chemically and bacterially at the Lawrence Experiment Station,	2,210
Number of samples of sand examined chemically at the Lawrence Experiment Station,	84
Number of samples of sand examined mechanically at the Lawrence Experiment Station,	67
Additional samples examined bacterially at the Lawrence Experiment Station,	826
Samples of water, ice, etc., examined for B. coli at the Lawrence Experiment Station,	5,179
Number of shell-fish examined for B. coli,	370
Samples examined for sewage Streptococcus at Lawrence Experiment Station,	4,204
Number of samples examined for B. sporgenes at Lawrence Experiment Station,	366
Total number of samples examined,	18,216

Force employed at central office: —		
Chief engineer,	1	
Assistant engineers,	6	
Stenographers and clerks,	3	
Messenger,	1	
	—	11

At laboratory, Room 502, State House: —		
Chemist,	1	
Assistant chemists,	5	
Biologist,	1	
Stenographer,	1	
	—	8
At Lawrence Experiment Station: —		
Assistant chemists,	2	
Bacteriologists,	2	
Other assistants and laborers,	3	
	—	7
		—
Total ordinary force,		26

The number of applications for advice under the provisions of the acts relating to water supply and sewerage, received since July, 1886, when these acts first went into operation, is as follows: —

1886,	8	1891,	53	1896,	65	1901,	105
1887,	22	1892,	56	1897,	59	1902,	93
1888,	28	1893,	51	1898,	75	1903,	129
1889,	38	1894,	53	1899,	79		——
1890,	23	1895,	52	1900,	104	Total,	1,093

Appropriations.

The appropriations for the year 1903, as recommended by the Board in the annual estimates made under the provisions of chapter 6, section 26, of the Revised Laws, were as follows: —

For the general expenses of the Board,	$23,000 00
For the inspection of food and drugs,	12,500 00
For the protection of the purity of inland waters,	34,000 00
For the examination of sewer outlets and Neponset River,	7,500 00
Printing annual report,	4,000 00
Total,	$81,000 00

Expenditures.

The expenditures in 1903 under the different appropriations were as follows: —

Appropriation for general expenses of Board, ... $23,000 00

General Expenditures, Sept. 30, 1902, to Sept. 30, 1903.

Salaries,	$11,703 36
Travelling expenses,	806 73
Stationery,	93 47
Printing,	1,088 56
Books, subscriptions and binding,	334 65
Advertising,	49 07
Amount carried forward,	$14,075 84

Amount brought forward,	$14,075 84	
Express charges,	166 91	
Extra services,	236 79	
Messenger,	73 60	
Postage and postal orders,	270 85	
Telephone and telegraph messages,	73 20	
Typewriter supplies,	2 00	
Special investigations,	125 65	
Sundry office supplies and incidental expenses,	776 50	
Laboratory supplies,	193 49	
Labor,	414 97	
		$16,409 80

Expenditures at Pathological Laboratory at Forest Hills.

Salaries,	$3,620 00	
Purchase of animals,	97 40	
Board of horses,	1,060 94	
Shoeing horses,	3 00	
Food for animals,	77 13	
Apparatus, chemicals and laboratory supplies,	464 02	
Ice,	13 44	
Postage,	98	
Stationery,	10 00	
Rental of telephone, and messages,	168 43	
Services of veterinary surgeon,	2 00	
Travelling expenses,	2 80	
Express charges,	4 93	
		5,525 07
Total,		$21,934 87

Under the Provisions of the Food and Drug Acts during the Year ending Sept. 30, 1903.

Appropriation,	$12,500 00
Salaries of analysts,	$4,629 99
Salaries of inspectors,	4,503 33
Travelling expenses and purchase of samples,	1,919 02
Apparatus and chemicals,	308 05
Printing,	61 59
Special investigations,	25 00
Services (cleaning laboratory),	104 00
Express and telegrams,	7 71
Sundry laboratory supplies,	100 84
Books,	39 90
Extra services (stenographer),	12 00
Total,	$11,711 43

The foregoing account of expenditures for general purposes and for food and drug inspection relates to the year ended Sept. 30, 1903.

Appropriation.

For carrying out the provisions of the *act to protect the purity of inland waters*, and to require consultation with the State Board of Health regarding the establishment of systems of water supply, drainage and sewerage,	$34,000 00

Salaries, including wages of laborers at Lawrence Experiment Station,	$24,996 59
Apparatus and materials,	3,302 17
Rent of Lawrence Experiment Station,	150 00
Use of tools and office, Lawrence Experiment Station,	268 47
Travelling expenses,	2,973 65
Express charges,	929 37
Books, stationery and drawing materials,	431 07
Maps and blue-prints,	67 72
Services, collecting samples,	35 80
Telephone and telegraph messages,	49 26
Special investigations,	529 21
Services, reading gauges,	108 00
Printing,	158 35
Total,	$33,999 66

The foregoing statement of expenses under the act to protect the purity of inland waters refers to the calendar year 1903.

Appropriation.

For the examination of sewer outlets under the provisions of section 4 of chapter 75 of the Revised Laws,	$7,500 00

Salaries,	$5,624 34
Apparatus and materials,	125 35
Travelling expenses,	1,482 30
Stationery and drawing materials,	75 70
Books, maps and blue-prints,	109 34
Printing,	24 59
Services, reading gauges and collecting samples,	52 95
Sundry office supplies,	4 95
Total,	$7,499 52

HENRY P. WALCOTT.
HIRAM F. MILLS.
GERARD C. TOBEY.
JAMES W. HULL.
CHARLES H. PORTER.
JULIAN A. MEAD.
JOHN W. BARTOL.

WATER SUPPLY AND SEWERAGE.

ADVICE TO CITIES AND TOWNS.

ADVICE TO CITIES AND TOWNS.

Under the provisions of the Revised Laws (chapter 75, section 117) the State Board of Health is required to

consult with and advise the authorities of cities and towns and persons having, or about to have, systems of water supply, drainage or sewerage as to the most appropriate source of water supply, and the best method of assuring its purity or as to the best method of disposing of their drainage or sewage with reference to the existing and future needs of other cities, towns or persons which may be affected thereby. It shall also consult with and advise persons engaged or intending to engage in any manufacturing or other business whose drainage or sewage may tend to pollute any inland water as to the best method of preventing such pollution, and it may conduct experiments to determine the best methods of the purification or disposal of drainage or sewage. No person shall be required to bear the expense of such consultation, advice or experiments. Cities, towns and persons shall submit to said board for its advice their proposed system of water supply or of the disposal of drainage or sewage, and all petitions to the general court for authority to introduce a system of water supply, drainage or sewerage shall be accompanied by a copy of the recommendation and advice of said board thereon.

During the year 1903 the Board has given its advice to the following cities, towns and persons who have applied for such advice under the provisions of this act or under special acts relating to water supply and sewerage.

Official communications were made during the year under the provisions of acts relating to water supply and to sources of ice supply, as follows: —

WATER SUPPLY.

Abington and Rockland.
Adams Fire District.
Amherst (two).
Arlington (Robbins Spring Water Company).
Ashfield (two).
Athol.
Attleborough.
Barnstable.
Belmont (Delano Moore).
Bolton (Guy F. Emerson).
Braintree.
Cambridge.
Cambridge (J. S. Bell Confectionery Company).
Colrain (Griswoldville).
Concord (Massachusetts Reformatory).
Concord (Middlesex School).
Conway.
Danvers (Insane Hospital).

East Bridgewater (Town Farm).
Fall River.
Fitchburg (two).
Gardner (Central Oil and Gas Stove Company).
Great Barrington (two).
Hingham.
Holyoke (two).
Hull (Fort Revere).
Hyde Park (B. F. Sturtevant Company).
Lawrence (two).
Lawrence (Everett Mills).
Lincoln.
Littleton.
Lowell.
Lowell (Lowell Textile School).
Lynn.
Marion (New York, New Haven & Hartford Railroad Company).
Marlborough.
Medfield.
Merrimac (two).
Metropolitan Water District (slaughter house of A. M. Richards, West Sterling).
Middleborough.
Monson (Hospital for Epileptics) (two).
Montague (Miller's Falls Company).
Montague (Turner's Falls).
Nantucket (two).
Nantucket (R. E. Burgess).
Natick (E. Edwards & Sons).
Needham.
Newburyport.
North Adams (G. L. Rice, M.D.).
Northfield (A. G. Moody).
Peabody.
Pittsfield.
Plymouth (Plymouth Mills).
Reading.
Rockport.
Russell.
Russell (Woronoco Paper Company).
Salem.
Sharon (two).
Southbridge (American Optical Company).
South Hadley (school committee).
Springfield (two).
Sterling (Sterling Inn).
Stoughton.
Uxbridge.
Waltham.
Wayland.
Wellesley (Wellesley College).
Westford (Caleb L. Smith).
Westwood (school committee).
Weymouth.
Wilbraham (L. E. Taft).
Williamsburg (two).
Williamstown.
Woburn.
Wrentham.

Ice Supply.

Cohasset (two).
Fall River.
Gloucester (two).
Huntington.
Quincy (two).
South Hadley (Charles Huot).
Stoughton.

Official communications were made during the year under general and special acts relating to sewerage and sewage disposal, as follows: —

Bridgewater.
Chicopee.
Easthampton (two).
Fitchburg.
Framingham (State Normal School).
Gardner (State Colony for Insane).
Haverhill.
Hinsdale (Hinsdale Creamery Association).
Hudson.
Lancaster.
Lancaster (State Industrial School).
Lenox.
Leominster.

Manchester.
Marblehead.
Newbury (Dummer Academy).
Northampton (two).
Pittsfield.
Revere.
Rutland (State Sanatorium).
Rutland (private hospitals).
Salem.
Sunderland.
Walpole (F. W. Bird & Son).
Wellesley (Wellesley College).
Westborough (Insane Hospital).
West Boylston (Worcester County Truant School).

Replies were also made in answer to applications for advice relative to the pollution of ponds, streams and other bodies of water, as follows: —

Medway.
North Attleborough.
Northborough.
Wellesley (three).
Westborough (Insane Hospital).
Worcester.

WATER SUPPLY.

The following is the substance of the action of the Board during the past year in reply to applications for advice relating to water supply: —

ABINGTON AND ROCKLAND.

Under the provisions of section 113 of chapter 75 of the Revised Laws rules and regulations were made by the Board on April 2, 1903, for preventing the pollution and securing the sanitary protection of the waters of Great Sandy Bottom Pond and its tributaries used by the towns of Abington and Rockland as a source of water supply.

APRIL 2, 1903.

To the Boards of Water Commissioners of the Towns of Abington and Rockland.

GENTLEMEN: — In accordance with your petition, received Jan. 26, 1903, requesting this Board to make rules and regulations to prevent the pollution and secure the sanitary protection of the waters used for the supply of the towns of Abington and Rockland, the Board has examined the conditions prevailing in the neighborhood of your source of supply, and has adopted rules and regulations, copies of which are sent you herewith.

On account of the very large number of people who resort to the shores of Great Sandy Bottom Pond in the summer season, and especially to the ponds which are at times tributary to Great Sandy Bottom Pond, and on account of the presence of large numbers of people at times about the cranberry bogs near the latter pond, there will be great and increasing difficulty in preventing all pollution of your sources of supply, unless you can prevent the use of these ponds and the lands about them as at present by purchasing the lands and buildings along their shores. While it may be practicable to do this, the expense is likely to be very considerable; and the Board would suggest that it is possible that your water supply can be effectually protected at less expense in another way.

An examination of the lands in the neighborhood of Great Sandy Bottom Pond and the other ponds which are tributary to it shows that the soil is largely coarse and porous, so far as can be judged from surface indications, and favorable to obtaining large quantities of water from the ground near the ponds by means of wells or other suitable works. While it appears that an attempt was made when your works were first constructed to obtain a supply from a filter-gallery located near the present pumping station, which resulted unfavorably on account of the fact that the material here was found to be too fine to allow water to pass freely, it is nevertheless possible that more favorable results might be obtained at other places in this neighborhood.

The Board would therefore advise that, before taking any further measures for protecting your supply than by carrying out the enclosed rules and regulations, you cause investigations to be made, with the aid of an engineer of experience in investigations relating to ground-water supplies, to determine the feasibility and probable cost of obtaining an adequate supply of water for Abington and Rockland from wells or other suitable works in the region near your present source. If a supply of good ground water could be obtained in this neighborhood, it would be far more satisfactory for domestic purposes than the waters of Great Sandy Bottom Pond, on account of the freedom of the water at all times from color or suspended matters and from taste and odor.

If you decide to make such investigations, the Board will, if you request, give you such assistance as it can by making all necessary analyses of water, and will give you further advice in the matter when the results of investigations are available.

ADAMS.

DEC. 3, 1903.

To Mr. F. W. SPALDING, *Treasurer, Adams Fire District, Adams, Mass.*

DEAR SIR: — In response to your request of November 14 for an examination of the water of the wells at Zylonite, formerly used as an auxiliary water supply for Adams, the Board has caused the wells to be examined and a sample of the water to be analyzed.

The results of the recent examination show that the water is very hard, but that its quality has not changed materially since it was examined by this Board in April, 1895. The hardness of the water would make it objectionable for many purposes, and it is not a desirable drinking water on this account.

It is very important to keep polluting matters from entering or being thrown into the basins or reservoirs in which the water is now collected, and it is also important that all sewage or other wastes from the factory be removed from the neighborhood of the wells to some suitable place of disposal where they will not affect the quality of the water.

The water of the public water supply of Adams is of better quality for drinking than the water furnished by these wells.

AMHERST.

FEB. 5, 1903.

To Messrs. IRWIN & HARDY, *Attorneys for Amherst Water Company, Amherst, Mass.*

GENTLEMEN: — The State Board of Health received from you on Dec. 24, 1902, a communication giving notice of the intention of the Amherst Water Company to secure, for use as sources of water supply for the town of Amherst, the pond known as Atkins Pond and two small brooks in the town of Shutesbury; and in response to this application the Board has caused the sources indicated to be examined by its engineer and samples of their waters to be analyzed.

Atkins Pond and the two brooks indicated by you, which unite to form Nourse Brook, so called, which flows near the pond at a somewhat higher level, would, taken together, furnish a large additional water supply for the town of Amherst.

The results of analyses show that the waters of the brooks, at the time they were examined early in January, 1903, were nearly colorless and contained little organic matter. It is not practicable to tell, however, from an examination made at this season of the year, whether the quality of these waters would be satisfactory at other seasons, and it has also been impracticable to determine whether they are exposed to serious danger of pollution.

The water of Atkins Pond was found upon analysis to contain a somewhat larger quantity of free ammonia than is generally present in a good pond water. The pond appears to be quite shallow, and the water of many such ponds is objectionable for drinking during the warmer portion of the year, on account of a bad taste or odor, due to the presence of excessive numbers of organisms. It is necessary that further examination be made of this source at a time when the pond is free from ice, in order to determine whether, if it should be used as a storage reservoir in connection with the brooks indicated, it will furnish water of good quality for domestic purposes.

While it is probable that, by the use of these sources in connection with the present sources of supply of the Amherst Water Company, a material increase can be made in the quantity of water available for the supply of the town, it is important, in the opinion of the Board, for the reasons indicated, that a further examination of the proposed sources be made before they are used. The Board will, if you so request, make a further examination of Atkins Pond and the brooks indicated at a more favorable season of the year, and will give you further advice concerning them.

DEC. 3, 1903.

To the Amherst Water Company, Amherst, Mass.

GENTLEMEN: — The State Board of Health has considered your application of November 10, requesting an examination of your sources of water

supply, and advice as to the cause of the taste and odor which have of late caused the water to be objectionable to consumers; and has caused the reservoir and its surroundings to be examined and samples of the water to be analyzed.

The results of the analyses of samples of water collected in the early part of October show that at that time microscopical organisms of kinds which have been known to produce objectionable tastes and odors in the waters of ponds and reservoirs were present in this water, and it is to the presence of these organisms that the disagreeable taste and odor of the water were probably largely due. At the time the recent examination was made the upper reservoir had been drawn off, and it was found that there was a considerable growth of filamentous algæ around the sides of the reservoir and on the bottom in the shallower portions, and this growth doubtless contributed to the objectionable condition of the water.

The bottom of the reservoir contains much mud and organic matter, including many stumps of trees which covered the area before it was flooded; and the presence of this organic matter is doubtless one of the chief causes of the objectionable organic growths in the water. A great improvement in the quality of the water can without doubt be made by removing this organic matter from the bottom of the reservoir, or by covering it so as to prevent it from coming in contact with the water; but it is not practicable to make these improvements in winter, and, in order to do this in a thorough manner, it will be necessary to draw off the reservoir in the drier portion of the year.

The Board is informed that the supply of water furnished by the present sources was barely sufficient for the requirements of the town during a dry season several years ago; and, while no records of the consumption of water are kept, the indications are that the consumption is increasing with the growth of the town, and that, if another dry year should occur, the present sources would be inadequate for the supply of the town.

It is impossible, under the circumstances, to draw off the reservoir and properly prepare its bottom for the storage of water until a new source of supply has been made available, without causing a very serious shortage of water in the town; and there is much danger, even under present conditions, that, unless the filling of the reservoir is begun again promptly, difficulty may be experienced in furnishing a sufficient quantity of water to the town at the present time.

The Board would advise that you first introduce an additional supply of water capable of furnishing all of the water required by the town for a sufficient period, and that you then draw off the present reservoir and make the necessary changes and improvements in its bottom.

The water-shed from which your present supply is taken contains a considerable number of dwelling houses and other buildings, some of which are so situated that there is great danger that sewage or polluting matter

from them may find its way directly into the streams which feed your reservoirs. The Board would advise that all the possible sources of pollution within the water-shed be carefully investigated, and the necessary measures taken to prevent the pollution of the water. It would be desirable to secure rules and regulations for the protection of your sources of supply, under the provisions of chapter 75 of the Revised Laws of Massachusetts.

ARLINGTON (ROBBINS SPRING WATER COMPANY).

MAY 7, 1903.

To the Robbins Spring Water Company, MR. WILLIAM H. HAMLEN, *Manager, Arlington, Mass.*

GENTLEMEN: — In response to your request of April 15 for a further examination of the water of certain springs in Arlington which are used as sources of spring water supply, the Board has caused the springs and their surroundings to be examined, and has analyzed a sample of water from two of the springs.

It appears from the information furnished by you that a house, formerly located near the springs, has been moved to a considerable distance and connected with a sewer; and that the use of water from the lower springs has been discontinued, so that water is now taken only from springs numbered 1, 2 and 3, which are farther from possible sources of pollution than the other springs.

The results of the recent analysis of the water flowing from springs 1 and 3, the sources in use at the time this examination was made, show that the water is of good quality for drinking, and is better than when the lower springs were used in connection with these upper springs.

ASHFIELD.

OCT. 1, 1903.

To the Board of Directors of the Ashfield Water Company, Ashfield, Mass.

GENTLEMEN: — The State Board of Health received from you, on September 11, the following application for the advice and approval by the Board of the taking of the water of Taylor Brook and its tributaries as a source of water supply for domestic purposes for the town of Ashfield: —

The Ashfield Water Company, incorporated under chapter 217, Acts of 1903, requests the consent and approval of the State Board of Health for taking the waters of Taylor Brook and the tributaries thereof for domestic purposes, extinguishment of fires and other purposes, as stated in said act, and according to plans of E. C. & E. E. Davis, engineers.

It is proposed to construct a reservoir on said Taylor Brook, containing about 4,000,000 gallons, to conduct the water thence through 6,000 feet of four-inch pipe to a service reservoir on Belding's Hill, containing about 500,000 gallons, to conduct the water thence through eight, six and four inch pipes to the village of Ashfield.

The proposed reservoir at Taylor Brook will be at a nominal elevation of 260

feet, the proposed service reservoir at an elevation of 180 feet, the general elevation of Ashfield village being 0 feet. The village supplied comprises about 75 houses.

The Board has caused the proposed source of supply to be examined by its engineer and samples of the water to be analyzed, and has examined the plans of the proposed works submitted by you and the other available information as to the proposed source of supply.

The water-shed of Taylor Brook does not probably exceed .3 of a square mile in area, but by constructing a reservoir to hold 4,000,000 gallons of water, as proposed, the source will probably be capable of yielding a sufficient quantity for the supply of the village of Ashfield, unless there should be a considerable increase in the number of dwelling houses and the population.

The results of analyses of the water of Taylor Brook show that it is naturally of good quality for the purposes of a public water supply; but at the present time sewage from two groups of farm buildings, located near the upper end of the water-shed, finds its way through drains directly into Taylor Brook. If this brook should be used as a source of water supply, under these conditions, there would be much danger that the health of the inhabitants of Ashfield would be injured thereby. It appears to be practicable to lay a sewer from these buildings to convey the sewage and polluting drainage in a westerly direction to some point outside of the water-shed, and in this way prevent the danger of pollution of the water by sewage; and it is possible that the danger could be prevented in some other way, such as by the purification of the sewage or the purchase and removal of the buildings.

Under the existing conditions, the Board is unable to approve the use of Taylor Brook as a source of water supply for domestic purposes at the present time, but will give the question of the approval of these plans further consideration if some provision shall be made in them for preventing the pollution of Taylor Brook or its tributaries by sewage.

Nov. 5, 1903.

To the Ashfield Water Company, Ashfield, Mass.

Gentlemen: — The State Board of Health has considered your application for advice with reference to a proposed water supply for the town of Ashfield, in which you mention as possible sources of supply Taylor Brook, Bear Swamp Brook, Creamery Brook and Great Pond, all in the town of Ashfield, and has caused the proposed sources of supply to be examined by its engineer and samples of their waters to be analyzed.

The results of the analyses show that the waters of all of the sources mentioned are naturally of good quality for the purposes of a public water supply.

The use of Taylor Brook as a source of supply is objectionable, however, as stated in a previous communication of the Board, on account of the

presence of two groups of farm buildings on the water-shed, drainage from which pollutes the streams.

Creamery Brook, taken at a point above the highway crossing near the upper end of the brook, would furnish water of good quality, and the source is not exposed to danger of sewage pollution, since the water-shed is uninhabited; but the area of the water-shed is so small that a reservoir of considerable size would be necessary in order to secure a sufficient quantity of water from this source for the supply of Ashfield, and it is doubtful whether the source could be so developed as to furnish, at reasonable cost, a sufficient quantity of water in very dry seasons.

The water-shed of Bear Swamp Brook is uninhabited, and consists almost wholly of woodland. Its area is considerably greater than that of the other brooks mentioned in your application, and there is an excellent opportunity for the construction of a storage reservoir of considerable size upon this water-shed, if such a reservoir should ever become necessary; but it is probable that a sufficient supply of water for the village of Ashfield can be obtained from this source by the construction of a small basin just below the old dam near the highway crossing on this brook.

Great Pond would furnish water of good quality for domestic purposes, and, while the water-shed contains dwelling houses and other buildings, the water of this source could be protected from pollution; but pumping would be necessary in order to obtain a supply from this source, and the cost would be likely to be considerably greater than the cost of a supply from Bear Swamp Brook.

Considering all the circumstances, the Board is of the opinion that Bear Swamp Brook is the most appropriate source of water supply for the village of Ashfield.

ATHOL.

APRIL 2, 1903.

To the Athol Water Company, MR. LYMAN P. HAPGOOD, *Superintendent, Athol, Mass.*

GENTLEMEN: — The State Board of Health has considered your application for advice with reference to a proposed additional water supply for the town of Athol, to be obtained by the construction of a large storage reservoir on Buckman Brook, so called, one of your present sources of supply, and has caused the location of the proposed source to be examined by its engineer.

The plan provides for the construction of a dam on Buckman Brook, a short distance below the present small reservoir on that stream, which will form a reservoir having an area of 15 acres and a capacity of 76,000,000 gallons.

The water-shed of Buckman Brook above the proposed reservoir contains very little swamp land, and the water of the streams is naturally of good quality. The only source of sewage pollution to which the water appears to be exposed is a group of farm buildings above the reservoir. The Board

is informed that you propose to acquire these buildings and remove them, and when this is done the danger of pollution of the water of the streams flowing into the proposed reservoir from existing dwelling houses or other buildings will be removed.

An examination of the proposed reservoir, which is already partially constructed, shows that much of the vegetable matter and peaty and loamy soil which would be liable to injure the quality of the water stored in the reservoir has been removed; but a small amount of organic matter, chiefly in the form of roots, and of soil containing organic matter, still remains. It is advisable, in the opinion of the Board, that all peat or mud should be removed from the reservoir before it is flowed, and exposed roots removed; and if this is done, it is likely that a water of good quality will be obtained from this source.

No information is available as to the quantity of water used for the supply of the town, or as to the yield of the present sources of supply. So far as can be judged from the information available, the yield of the Buckman Brook and Phillipston reservoir sources taken together should be ample, after the proposed new reservoir is completed, for the present requirements of Athol. The water of the Phillipston reservoir is, however, very objectionable for drinking and other domestic purposes, during the warmer portion of the year at least, on account of the presence of very large numbers of microscopical organisms, which impart to the water an offensive taste and odor. The filters at present in use for the removal of this organic matter are not capable of purifying the water satisfactorily in the summer season, and more efficient purification of the water of this source is necessary, in order to remove the objectionable taste and odor by which it is now frequently affected. There appears to be a good opportunity for providing suitable filters by which this water can be efficiently purified at less expense than the cost of maintaining and operating the present filters; and the Board would advise that you consider the feasibility of purifying this water by filters located below the gate-house through which the water of the Phillipston reservoir is drawn. The Board will advise you as to any plan for the purification of this water that you may desire to present.

ATTLEBOROUGH.

Under the provisions of section 113 of chapter 75 of the Revised Laws, rules and regulations were made by the Board on July 2, 1903, for preventing the pollution and securing the sanitary protection of the waters of Orr's Pond and its tributaries, used by the town of Attleborough as a source of water supply.

JULY 2, 1903.

To the Board of Water Commissioners of the Town of Attleborough.

GENTLEMEN: — The State Board of Health has considered your request of May 23, that rules and regulations be prepared for the sanitary protec-

tion of Orr's Pond in Attleborough, which is adjacent to the well from which your supply of water is now drawn, and has caused the locality to be examined by its engineer.

The Board is informed that the yield of the well from which your supply is now drawn is but little if any in excess of the quantity of water used to supply the town, and that you propose to use water from Orr's Pond at the point where the Seven Mile River enters it, where a pipe has already been provided for the purpose. In the opinion of the Board, it will be impracticable to enforce the rules now sent you so thoroughly as to prevent all danger of pollution of the Seven Mile River and Orr's Pond except at a large expense; and Orr's Pond is not, in the opinion of the Board, a safe source from which to take water directly for the supply of Attleborough. It is also of objectionable quality in other respects, and its objectionable qualities would be the more noticeable to consumers, since the water of your present well is at all times clear and colorless, and of excellent quality when supplied through proper pipes.

The conditions in the region about your present well appear to be favorable to obtaining water freely from the ground, and it is probable that another well or wells could be located in this neighborhood which would materially increase the capacity of your works, and make it unnecessary to draw from Orr's Pond; and, considering the circumstances, the Board would advise that you make investigations without delay, to determine whether it may not be feasible to increase the available supply of ground water near your pumping station, and avoid any necessity for drawing water directly from Orr's Pond.

In view of the circumstances, the Board has adopted rules and regulations for the sanitary protection of Orr's Pond and its tributaries, which you can enforce temporarily until you have completed another well or wells and enlarged your sources sufficiently to make it unnecessary to draw water directly from Orr's Pond.

Barnstable.

Feb. 5, 1903.

To Eben Thacher, Henry B. Nickerson and Frederick H. Armstrong, *Hyannis, Mass.*

Gentlemen: — The State Board of Health received from you, on Dec. 17, 1902, an application for advice with reference to a supply of water for the town of Barnstable, to be taken from Wequaket Lake in that town, the point of taking being indicated on a plan submitted with your application; and in response to this application the Board has caused the proposed source of water supply to be examined by its engineer, and has considered your proposed plan.

The water of Wequaket Lake, which is also known as Nine Mile Pond, is ordinarily clear and nearly colorless, and, so far as can be judged from the single analysis that has been made, is naturally of good quality for the

purposes of a public water supply; though it is likely that the water of this source, in common with that of most similar sources, is affected at times by a noticeable taste and odor, due to the presence of considerable numbers of certain kinds of microscopic organisms.

At the present time there are many camps and boat houses about the shores of the lake, and large numbers of people resort to the lake for boating and fishing in the summer season; and, if the lake should be used as a source of public water supply, as proposed, it would be necessary to restrict greatly the use of the lake as a summer resort, in order to prevent pollution of the water.

An examination of the territory about the lake and of lands in the neighborhood of Hyannis and Centerville shows that the soil is coarse and porous, and it is likely that an ample quantity of water for the supply of the town could be obtained without special difficulty at any one of several places in this neighborhood. A supply of ground water would be more satisfactory for domestic water-supply purposes than the water of the lake proposed in your application, because it would have a lower temperature in the summer season, would be free at all times from a taste or odor, and would not, like the pond, be exposed to danger of pollution; and it is likely that such a supply could be obtained at less expense, all things considered, than a supply of water from Wequaket Lake.

Considering the circumstances, the Board does not at present advise the construction of works for taking water from Wequaket Lake, but advises that you cause investigations to be made as to the feasibility of obtaining a ground-water supply from some convenient place where the conditions appear to be favorable for obtaining such a supply.

Belmont (Delano Moore).

April 2, 1903.

To Mr. Delano Moore, *Lawrence, Mass.*

Dear Sir: — In response to your request of February 16 for advice as to the quality of the water of a spring located in the north-westerly part of Belmont, on land of H. Shaw, about 400 feet north of Marsh Street and half a mile west of Prospect Street, from which you propose to sell water for drinking, the State Board of Health has caused the spring and its surroundings to be examined and a sample of its water to be analyzed.

The results of the analysis show that the water is of suitable quality for drinking purposes at the present time. The water-shed is free from buildings, and the only conditions which appear likely to affect unfavorably the quality of the water at the present time are the use of the land in the neighborhood of the spring for pasturage, and the possible danger that the water of the brook which flows near the spring may at times of high water enter the spring. By preventing danger of the pollution of the source from these causes, this spring may be used as a source of drinking water supply with safety.

BOLTON (GUY F. EMERSON).

AUG. 6, 1903.

MR. GUY F. EMERSON, *Hudson, Mass.*

DEAR SIR: — In response to your request of July 8 for advice as to the quality of the water of a spring in Bolton, from which you propose to sell water for drinking, the Board has caused the spring and its surroundings to be examined and a sample of the water to be analyzed.

It appears that the spring is located about two and one-half miles east of the village of Bolton, on the slope of a hill about one-fourth of a mile south-east of the road leading from Hudson to Stow, near the place where this road is joined by the "Long Hill" road.

The sample of water collected from the spring, which at the present time is not covered, shows that the water is of good quality, though the quantity of organic matter present is larger than is found in good spring waters. The presence of this excess of organic matter is probably due to the fact that the spring is unprotected from sunlight and from matters which might fall or be washed into it from the ground about it. By covering the spring so as to exclude light and prevent the entrance of surface water this spring will furnish water of good quality for drinking.

The land between the spring and the top of the hill is free from buildings, and the spring is not exposed to danger of sewage pollution at the present time. The use of the ground about the spring for pasturage should be prevented.

The Board would advise that all lead pipes at present in use be removed, and that the use of lead pipe for conveying the water in future be avoided.

BRAINTREE.

MAY 7, 1903.

To the Water Supply Committee of the Town of Braintree, MR. JAMES T. STEVENS, *Chairman.*

GENTLEMEN: — The State Board of Health received from you, on April 1, 1903, an application for advice relative to an additional and improved water supply for the town of Braintree, accompanied by a report of your committee and of your engineer, Mr. William Wheeler of Boston, containing the results of investigations of the various sources available to the town, and estimates of the cost of an additional water supply by several plans, including a supply from Great Pond in Randolph and Braintree, either alone or in connection with your other sources, and a supply from the metropolitan water district.

In response to your application, the Board has caused the sources available for the supply of the town to be examined by its engineer, and has carefully considered the results of previous investigations of these sources and the reports and information submitted by your committee.

Experience with the filter-gallery and wells near Little Pond has already

shown clearly that they are incapable of supplying a sufficient quantity of water for the needs of the town in the drier part of the year; and, even if water should be drawn directly from Little Pond, the yield of the works would still be insufficient for the town in a dry period.

The Board has already, in previous communications, called attention to the serious pollution of Little Pond from the large population on its water-shed, and to the danger of using this pond as a source of domestic water supply without purifying the water. The water of the filter-gallery and tubular wells is also affected by the large quantity of sewage discharged into the ground from the population adjacent to the pond on the side upon which these works are located, and by imperfectly filtered pond water; and, as you have already been advised, while this water may not at present be unsafe for drinking, the circumstances attending its pollution are such that it is liable to become unsafe at any time.

Great Pond, the source of water supply now used by the towns of Randolph and Holbrook, is also available as a source of supply for Braintree, and it appears that the three towns have rights to equal shares of its waters. This pond is situated at such an elevation that it is practicable to draw water from it to your present pumping station by gravity, and it is probable that the source is capable of furnishing a sufficient supply of water for Braintree for the next twenty years or more, allowing for a reasonable growth in population and in the use of water, and for the quantity of water which may be diverted by the towns of Randolph and Holbrook.

The water-shed of Great Pond contains much of the thickly populated portion of the town of Randolph, and, when the pond was first proposed as a source of water supply for Randolph and Holbrook, this Board advised that measures be taken for removing pollution from the pond by the construction of sewers to remove the sewage from thickly settled areas, but no sewers or works for preventing the pollution of the waters appear to have been constructed as yet. There are also several sources of pollution in the immediate neighborhood of the pond.

The water of the pond at times is quite highly colored and contains a large amount of organic matter, due to the presence of microscopic organisms in considerable numbers and to the contact of the water with vegetable matter in swamps on its water-shed and to the character of the pond itself, which is shallow with a muddy bottom over a large area. Owing to these conditions, the water of this pond, if used directly for the supply of the town, would be at times objectionable for drinking and for other domestic purposes on account of a disagreeable taste and odor, and might also be injurious to health unless adequate provision should be made to prevent its pollution by the population on its water-shed. The water can undoubtedly be efficiently purified by filtration so that it would be safe for drinking and free from objectionable taste and odor; and it appears, from

the information furnished by you, that it is practicable to locate suitable filters near your pumping station and to filter the water from Great Pond by gravity at this place.

By taking a supply of water from the metropolitan water supply district, an ample supply of good water could be obtained for Braintree; but the cost of a supply from this source, judging from the information available to the Board, would probably be much greater at the present time than the cost of taking water from Great Pond and purifying it by filtration near your present pumping station; and there would be no advantage in the quality of the water of the metropolitan district over the filtered water, if the filtration works were properly constructed and maintained.

Considering all the circumstances, the Board is of the opinion that the best plan for enlarging and improving the water supply of Braintree is to take water from Great Pond in Randolph and Braintree, and convey it to the neighborhood of your present pumping station and there purify it by filtration. Provision can be made also for drawing water from Little Pond, if necessary, since this water would be suitable for the purpose after filtration; but, on account of the necessity for pumping, the cost of using water from this source would be greater than the cost of the water from Great Pond.

It is very important also that suitable provision be made for preventing, so far as practicable, all pollution of Great Pond; and, if Little Pond is to be used as a source of supply, or the filter-gallery near it, a sewerage system should be provided for removing the sewage from the neighborhood of this pond.

CAMBRIDGE.

APRIL 2, 1903.

To Mr. WILLIAM B. DURANT, *President, Cambridge Water Board, Cambridge, Mass.*

DEAR SIR: — The State Board of Health received from you, on Jan. 30, 1903, a communication calling attention to certain slaughter houses in Weston on the premises of Messrs. Zoller, Hagar and Clark, drainage from which you believe is liable to pollute your water supply, and requesting this Board to cause the matter to be investigated, and take measures to restrain the use of these buildings for their present noxious purposes.

Soon after this application was made, on February 10, the Board caused the slaughter houses indicated to be examined by one of its engineers, to learn whether drainage or polluting matter from any of them was finding its way into Stony Brook storage reservoir or any of its tributaries. At this time there was no evidence that any stream or other open water which might at any time be tributary to any of the sources of water supply of Cambridge was being polluted by wastes from either of these slaughter houses.

Subsequently, on March 9, at the end of a heavy rain storm, a second examination was made, and samples of water collected for analysis from

the nearest streams which would be likely to be polluted from these slaughter houses if any drainage should escape therefrom; but at this time also no evidence was obtained which would indicate that polluting matters from either of the slaughter houses were affecting any of the streams in their neighborhood, though the stream in the rear of Clark's slaughter house was being polluted probably by drainage from the dwelling houses in Weston village along the southerly side of the main street above the slaughter house.

Subsequently, on March 23, a third examination was made, during a severe rain storm, and at this time also there was no evidence that polluting matters from these slaughter houses were finding their way into any of the streams in their neighborhood.

In view of the circumstances, the Board does not deem it necessary, for the protection of the water supply of Cambridge, to make any further order or regulation respecting the carrying on of business at these places at the present time.

Cambridge (J. S. Bell Confectionery Company).

Jan. 7, 1904.

To the J. S. Bell Confectionery Company, Cambridgeport, Mass.

Gentlemen: — In compliance with your request of Nov. 21, 1903, for advice as to the quality of the water of a tubular well from which you propose to take water for drinking purposes in your factory at Cambridgeport, the State Board of Health has caused the locality to be examined and a sample of water from the well to be analyzed.

The results of the analysis show that the water contains a large quantity of organic matter, and the number of bacteria present was high.

In the opinion of the Board, this well is an unsafe source from which to take water for drinking, and if this water is to be used for washing or cooling in the factory, it should be supplied in such a manner that it will not be accessible for drinking.

Colrain (Griswoldville).

Dec. 3, 1903.

To Mr. Lorenzo Griswold, *Treasurer, Griswoldville Manufacturing Company, Griswoldville, Mass.*

Dear Sir: — In response to your request of October 28 for an examination of the water of McClellan Brook and the Lorenzo Griswold Spring, used as sources of water supply in the village of Griswoldville, the Board has caused the sources and their surroundings to be examined and samples of their waters to be analyzed.

The results of the examination show that the water-sheds of both sources above the points at which these waters are taken are uninhabited, and their waters do not appear to be exposed to danger of pollution at the present time, and the analyses show that the waters of both sources are of good quality for drinking. It is very important that the water-sheds be kept free from pollution while these sources continue in use.

CONCORD (MASSACHUSETTS REFORMATORY).

NOV. 5, 1903.

To Mr. JOSEPH F. SCOTT, *Superintendent, Massachusetts Reformatory, Concord Junction, Mass.*

DEAR SIR: — The State Board of Health received from you, on Oct. 17, 1903, a communication stating that you have recently made tests near the reformatory, with a view to getting a water supply for the institution, and requesting the advice of the Board as to obtaining a ground-water supply from wells located on an island in Warner's Pond; and in response to this application the Board has caused the locality to be examined by its engineer, and samples of the water of three test wells located on the island, from which water could be pumped very freely, to be analyzed.

The results of the analyses indicate that water of good quality for drinking and other purposes in the reformatory may be obtained from the ground in this locality. A considerable quantity of iron was present in one of the wells, however, even after a considerable quantity of water had been pumped from the well; and it is not practicable to determine, from the investigation thus far made, whether the water would remain of good quality if a large quantity of water should be drawn continuously from the ground at this place.

The Board would advise, as the next step in this investigation, that you cause additional test wells to be put in and connected with a steam pump, and that you cause a pumping test to be made by pumping from a group of wells in this locality for a period of at least two weeks, and at a rate at least as great as would be necessary for the supply of the reformatory. In the course of this test samples of water should be taken at frequent intervals for analysis.

Should you decide to make a further test, the Board will, upon application, make the necessary analyses of samples of the water, and will then give you further advice as to the use of wells at this place as a source of water supply for the reformatory.

CONCORD (MIDDLESEX SCHOOL).

NOV. 5, 1903.

Mr. FREDERICK WINSOR, *Head Master, Middlesex School, Concord, Mass.*

DEAR SIR: — In response to a request received through your engineers for advice as to the quality of the water from a collecting trench approximately 1,000 feet in length, located near the foot of the hill north-east of the school, which you desire to use for drinking, the Board has caused the proposed source and the region about it to be examined by its engineer, and a sample of the water to be analyzed.

The results of the analysis show that the water is slightly turbid, and contains a slightly greater quantity of organic matter than is usually found in the best ground waters, — a condition which is probably due to the

fact that the collecting trench has only recently been completed, and that very little water has passed through the pipe from which the sample was collected.

The lands from which water would naturally percolate towards this trench are uninhabited and free from sources of pollution; and, considering all the circumstances, the Board is of the opinion that water from this source may safely be used for drinking.

CONWAY.

FEB. 5, 1908.

To Messrs. JOHN B. LAIDLEY, ARTHUR P. DELABARRE, FRED A. DELABARRE, *Conway, Mass.*

GENTLEMEN: — The State Board of Health received from you, on January 17, an application for its advice relative to a proposed water supply for the town of Conway, to be taken from Roaring Brook above the main road leading from Conway village to West Whately, and has caused the locality to be examined by its engineer, and a sample of the water of the brook to be analyzed.

The results of the analysis show that the water flowing in the brook at this time is of excellent quality for the purposes of a public water supply. The sample was doubtless affected by melting snow, and it is probable that the quality of the water is materially different at other seasons of the year; but, judging from the results of analyses of the water of this source further down stream, it is of good quality for domestic purposes at all times. Whether the quantity of water which this source will furnish will be sufficient for the requirements of Conway at all times will depend upon the flow of the stream in the drier portion of the year, or the practicability of the construction of a reservoir for the storage of water for use during periods of low flow. It is impracticable to make a sufficient examination at this season of the year to determine this question definitely; but, judging from the information available concerning this source, it is probable that it could be developed to furnish sufficient water for the requirements of Conway.

The Board has also caused examinations to be made of other streams in the neighborhood of Conway which appear to be available as sources of water supply for the village. One of these streams, flowing from a watershed on the south side of South River and discharging into South River a short distance above the covered bridge at Burkville, appears to be a favorable source from which to take a water supply for Conway. The watershed is somewhat larger than that of Roaring Brook above the West Whately road, and there is a favorable site for a reservoir not far above the point at which the waters of this source would naturally be taken if they were to be used for the supply of Conway. The cost of works for a supply from this source would apparently be considerably less than the cost of a supply from Roaring Brook.

Considering the circumstances, the Board would advise a further investigation of each source after the snow has disappeared, when the conditions are favorable for a thorough examination. The Board will, if you so request, assist you in these investigations, and give you further advice as to which of these sources will be likely to be the more appropriate one for the supply of Conway.

DANVERS (INSANE HOSPITAL).

SEPT. 3, 1903.

To the Trustees of the Danvers Insane Hospital, and CHARLES W. PAGE, M.D., *Superintendent, Danvers, Mass.*

GENTLEMEN: — The State Board of Health received from you, on Aug. 8, 1903, a communication requesting advice as to the propriety of taking water from the Ipswich River, for use, temporarily at least, in some new hospital buildings to be located near the river in the town of Middleton, and in response to this application has caused the locality to be examined by one of its engineers.

The Ipswich River, above the point at which the water would be taken for the supply of the hospital, is polluted at many places by sewage and manufacturing waste, and, in the opinion of the Board, would be a very unsafe source from which to take water for the supply of the proposed hospital buildings.

A supply of water of good quality is obtained for the present buildings from the public water works of the town of Danvers, and the sources used are of sufficient capacity to make it practicable for the town to furnish additional water to supply the proposed new hospital buildings, if necessary.

If a ground-water supply of good quality could be obtained, however, the water would be more satisfactory than that supplied to the present buildings; and it is possible that an independent supply of ground water could be obtained for the proposed new buildings at less expense than from your present works. A superficial examination of the ground in the neighborhood of the Ipswich River, above the place where it is crossed by the Salem and Lawrence railroad, indicates that the soil in this region may be coarse and porous to a considerable depth, and that it may be practicable to obtain water freely from the ground there by means of wells or other suitable works.

The Board would advise that you cause tests to be made of the ground in this region by means of tubular wells, to determine the character of the soil and the practicability of obtaining a supply of good water from the ground at this place. The Board will assist you in further investigations, if you so request, by making the necessary analyses of samples of water from test wells, and will give you further advice in the matter when you have the results of further investigations to present.

Definite plans for the disposal of the sewage of the hospital buildings have not been presented, but you have indicated to the engineer of the

Board a plan for disposing of the sewage from the proposed new buildings by discharging it upon the ground on the slope of the hill on which the buildings are situated. This method of disposal would be very objectionable. The sewage-disposal area of the hospital is of ample size for the purification of all of the sewage, both of the present and of the proposed new buildings; and, should the quantity of sewage be larger than is now expected, it is practicable to enlarge this area by building additional filters adjacent to the present area. The sewage discharged upon these filters at the present time is well taken care of and very efficiently purified. It appears to be practicable to convey the sewage of the proposed new buildings to these filters, and, in the opinion of the Board, this is the best plan of disposing of the sewage from these buildings.

East Bridgewater (Town Farm).

June 4, 1903.

To the Board of Health of the Town of East Bridgewater, Mr. J. W. Holloway, *Secretary*.

Gentlemen: — In accordance with your request of May 16, 1903, the State Board of Health has caused the well at the East Bridgewater town farm, used as a source of water supply for household purposes at that institution, to be examined and a sample of the water to be analyzed.

The results of the analysis show that the water of the well is colored and turbid, and contains a much larger quantity of organic matter than is found in good well waters, and that it is evidently polluted. The pollution of the water is probably derived from the barn near by, and possibly from other sources of pollution at no great distance.

The Board would advise that the further use of water from this well be prevented, and that water that is known to be safe for drinking be provided for the supply of this institution.

Fall River.

Under the provisions of section 113 of chapter 75 of the Revised Laws, the following rules and regulations were made by the Board on Dec. 3, 1903, for preventing the pollution and securing the sanitary protection of the waters of North Watuppa Pond and its tributaries, used by the city of Fall River as a source of water supply: —

Commonwealth of Massachusetts,
State Board of Health.

Rules and Regulations for the Purpose of preventing the Pollution and securing the Sanitary Protection of the Waters of North Watuppa Pond and its Tributaries, used by the City of Fall River as a Source of Water Supply.

The State Board of Health, acting under the authority of section 113 of chapter 75 of the Revised Laws, and every other act thereto enabling, hereby makes the following rules and regulations for the purpose of preventing the pollution and

securing the sanitary protection of the waters of North Watuppa Pond and its tributaries, used by the city of Fall River as a source of water supply, which shall remain in force until further order, and which may be hereafter from time to time amended or added to by the State Board of Health: —

1. No cesspool, privy or other place for the reception, deposit or storage of human excrement, and no urinal or water-closet not discharging into a sewer, shall be located, constructed or maintained within 50 feet of high-water mark of North Watuppa Pond, so called, said pond being in the city of Fall River and the town of Westport, and used by said city as a source of water supply, or within 50 feet of high-water mark of any reservoir, lake, pond, stream, ditch, water course or other open waters, the water of which flows directly or ultimately into said North Watuppa Pond.

2. No human excrement shall be deposited or discharged in or into North Watuppa Pond, so called, said pond being in the city of Fall River and the town of Westport, and used by said city as a source of water supply, or into any reservoir, lake, pond, stream, ditch, water course or other open waters, the water of which flows directly or ultimately into said North Watuppa Pond; and no human excrement shall be kept in, or deposited or discharged in or into, any cesspool, privy or other receptacle situated within 250 feet of high-water mark of said North Watuppa Pond, or within 250 feet of high-water mark of any open waters, the water of which flows directly or ultimately into said North Watuppa Pond, unless such cesspool, privy or other receptacle is so constructed that no portion of its contents can escape or be washed into any such waters.

3. No human excrement, or compost containing human excrement, or contents of any privy or cesspool or sewer, or other receptacle for the reception or storage of human excrement, shall be deposited or discharged upon or into the ground at any place from which any such excrement, compost or contents, or particles thereof, may flow or be washed or carried into North Watuppa Pond, so called, said pond being in the city of Fall River and the town of Westport, and used by said city as a source of water supply, or into any reservoir, lake, pond, stream, ditch, water course or other open waters, the water of which flows directly or ultimately into said North Watuppa Pond.

4. No house slops, sink waste, water which has been used for washing or cooking, or other polluted water, shall be discharged into North Watuppa Pond, so called, said pond being in the city of Fall River and the town of Westport, and used by said city as a source of water supply, or into any reservoir, lake, pond, stream, ditch, water course or other open waters, the water of which flows directly or ultimately into said North Watuppa Pond; and no house slops, sink waste, water which has been used for washing or cooking, or other polluted water, shall be discharged into the ground within 50 feet, or upon the ground within 250 feet of high-water mark of said North Watuppa Pond, or into the ground within 50 feet, or upon the ground within 250 feet, of high-water mark of any open waters flowing as aforesaid into said North Watuppa Pond.

5. No garbage, manure or putrescible matter whatsoever shall be put into North Watuppa Pond, so called, said pond being in the city of Fall River and the town of Westport, and used by said city as a source of water supply, or into any reservoir, lake, pond, stream, ditch, water course or other open waters, the water of which flows directly or ultimately into said North Watuppa Pond; and no garbage, manure or putrescible matter whatsoever shall, except in the cultivation and

use of the soil in the ordinary methods of agriculture, be put upon the ground within 250 feet of high-water mark of said North Watuppa Pond, or within 250 feet of high-water mark of any open waters flowing as aforesaid into said North Watuppa Pond.

6. No stable, pig-sty, hen-house, barn-yard, hog-yard, hitching or standing place for horses, cattle or other animals, or other place where animal manure is deposited or accumulates, shall be located, constructed or maintained, any part of which is within 50 feet of high-water mark of North Watuppa Pond, so called, said pond being in the city of Fall River and the town of Westport, and used by said city as a source of water supply, or within 50 feet of high-water mark of any reservoir, lake, pond, stream, ditch, water course or other open waters, the water of which flows directly or ultimately into said North Watuppa Pond. No stable or other place, as above enumerated, shall be located, constructed or maintained within 250 feet of high-water mark of said North Watuppa Pond, or within 250 feet of high-water mark of any open waters flowing as aforesaid into said North Watuppa Pond, unless suitable and adequate provision is made to prevent any manure or other polluting matter from flowing or being washed into said pond or such open waters.

7. No interment shall, except by permission in writing by the Watuppa Water Board of the city of Fall River, be made in any cemetery or other place of burial, within 50 feet of high-water mark of North Watuppa Pond, so called, said pond being in the city of Fall River and the town of Westport, and used by said city as a source of water supply, or within 50 feet of high-water mark of any reservoir, lake, pond, stream, ditch, water course or other open waters, the water of which flows directly or ultimately into said North Watuppa Pond.

8. No lands, which were not under the control of cemetery authorities and used for cemetery purposes on Dec. 3, 1903, from which the natural drainage flows into North Watuppa Pond, so called, said pond being in the city of Fall River and the town of Westport, and used by said city as a source of water supply, or into any reservoir, lake, pond, stream, ditch, water course or other open waters, the water of which flows directly or ultimately into said North Watuppa Pond, shall be taken or used for cemetery purposes until a plan and description of the lands which it is proposed to use for such purposes, sufficient for their identification, shall be presented to the State Board of Health, and until such taking or use shall be approved in writing by said State Board of Health.

9. No manufacturing refuse or waste products or polluting liquid, or other substance of a nature poisonous or injurious either to human beings or animals, or other putrescible matter whatsoever, shall be discharged directly into, or at any place from which it may flow or be washed or carried into, North Watuppa Pond, so called, said pond being in the city of Fall River and the town of Westport, and used by said city as a source of water supply, or into any reservoir, lake, pond, stream, ditch, water course or other open waters, the water of which flows directly or ultimately into said North Watuppa Pond.

10. No system of sewers or other works for the collection, conveyance, disposal or purification of domestic or manufacturing sewage or drainage, or any other putrescible matter whatsoever, shall, except in accordance with plans first approved in writing by the State Board of Health, be constructed or maintained at any place within the water-shed of North Watuppa Pond, so called, said pond

being in the city of Fall River and the town of Westport, and used by said city as a source of water supply. No private or separate sewer shall be constructed or maintained, having an outlet upon or in the ground, within 250 feet of high-water mark of said North Watuppa Pond, or within 250 feet of high-water mark of any reservoir, lake, pond, stream, ditch, water course or other open waters, the water of which flows directly or ultimately into said North Watuppa Pond.

11. No public or private hospital, or other place intended for the reception or treatment of persons afflicted with a contagious or infectious disease, shall, until the location and construction thereof have been approved in writing by the State Board of Health, be located or constructed at any place within the water-shed of North Watuppa Pond, so called, said pond being in the city of Fall River and the town of Westport, and used by said city as a source of water supply. No public or private hospital, or other place intended for the reception or treatment of persons afflicted with a contagious or infectious disease, shall be maintained at any place within such water-shed, unless all the provisions required by the State Board of Health for the purification or disposal of sewage, drainage or other polluting or organic matter, which may be discharged therefrom, have been complied with, and unless all orders issued from time to time by said State Board of Health in relation to the purification and disposal of sewage, drainage and other polluting or organic matter, which may be discharged therefrom, are fully complied with.

12. No tannery, currying shop or other establishment or place where the skin, wool, hair or fur of any animal is treated, shall, until the location and construction thereof have been approved in writing by the State Board of Health, be located or constructed at any place within the water-shed of North Watuppa Pond, so called, said pond being in the city of Fall River and the town of Westport, and used by said city as a source of water supply. No tannery, currying shop or other establishment or place where the skin, wool, hair or fur of any animal is treated, shall be maintained at any place within such water-shed, unless all the provisions required by the State Board of Health for the purification or disposal of sewage, drainage or other polluting or organic matter, which may be discharged therefrom, have been complied with, and unless all orders issued from time to time by said State Board of Health in relation to the purification and disposal of sewage, drainage and other polluting or organic matter, which may be discharged therefrom, are fully complied with.

13. No slaughter house or other building for carrying on the business of slaughtering cattle, sheep or other animals, and no melting or rendering establishment, shall, until the location and construction thereof have been approved in writing by the State Board of Health, be located or constructed at any place within the water-shed of North Watuppa Pond, so called, said pond being in the city of Fall River and the town of Westport, and used by said city as a source of water supply. No slaughter house or other building for carrying on the business of slaughtering cattle, sheep or other animals, and no melting or rendering establishment, shall be maintained at any place within such water-shed, unless all the provisions required by the State Board of Health for the purification or disposal of sewage, drainage or other polluting or organic matter, which may be discharged therefrom, have been complied with, and unless all orders issued from

time to time by said State Board of Health in relation to the purification and disposal of sewage, drainage and other polluting or organic matter, which may be discharged therefrom, are fully complied with.

14. No person shall bathe in, and no person shall, unless permitted by a special regulation or by a written permit of the Watuppa Water Board of the city of Fall River, fish in, or send, drive or put any animal into North Watuppa Pond, so called, said pond being in the city of Fall River and the town of Westport, and used by said city as a source of water supply. No person other than a member of said Watuppa Water Board, its officers, agents or employees, or public officers whose duties may so require, shall, unless so permitted by regulation or permit of said Board, enter or go, in any boat, skiff, raft or other contrivance, on or upon the water of said pond, nor shall enter or go upon, or drive any animal upon, the ice of said pond.

15. No person shall enter upon North Watuppa Pond, so called, said pond being in the city of Fall River and the town of Westport, and used by said city as a source of water supply, for the purpose of cutting or taking ice, or cut or take ice from said pond, without a written permit, signed by the Watuppa Water Board of the city of Fall River, stating the time and place for which such permission is given.

16. All reports which may be made to any board of health, or to any health officer of any city or town, of cases of contagious or infectious disease occurring within the water-shed of North Watuppa Pond, so called, said pond being in the city of Fall River and the town of Westport, and used by said city as a source of water supply, shall be open to the inspection at all reasonable times of the Watuppa Water Board of the city of Fall River, its officers or agents.

Fitchburg.

Under the provisions of chapter 448 of the Acts of 1902, rules and regulations were made by the Board on March 5, 1903, for the harvesting and storing of ice from Meetinghouse Pond in the town of Westminster, used by the city of Fitchburg as a source of water supply.

Under the provisions of section 113 of chapter 75 of the Revised Laws, rules and regulations were made by the Board, on July 2, 1903, for preventing the pollution and securing the sanitary protection of the sources of water supply of the city of Fitchburg.

Gardner (Central Oil and Gas Stove Company).

Feb. 5, 1903.

Central Oil and Gas Stove Company, Gardner, Mass.

Gentlemen: — The State Board of Health has considered your request for an examination of the water supply of your factory, taken from an underground source in School Street near Foundry Street, which it appears is used for drinking, and has caused a sample of the water to be analyzed.

The source from which the water is taken is apparently an underground channel, into which water is collected from the region between Chestnut and Elm streets. The region is densely populated, and, while most of the

buildings are apparently connected with the sewers, polluting matters are discharged upon the ground.

The results of the analysis of a sample of the water show that it contains much organic matter of unknown origin; but there are evidences that at least a portion of the water is polluted by sewage, and not thoroughly purified in its subsequent passage to the place from which it is drawn.

Considering the surroundings of this source of water supply and the character of the water as shown by the analysis, the Board does not consider it safe for drinking.

Great Barrington.

April 2, 1903.

To the Water Commissioners of the Great Barrington Fire District, Mr. Parley A. Russell, *Chairman.*

Gentlemen: — The State Board of Health received from you, in May last, a communication requesting the Board to examine Goodale Brook in the towns of Egremont and Mt. Washington, and advise you as to a proposed plan for using this stream as a source of water supply for the Great Barrington fire district. Subsequently you erected a weir on the stream, and have furnished the Board with the results of observations of the flow of the stream during the period from May to September, 1902.

In response to your application, the Board has caused Goodale Brook and the sites of proposed storage reservoirs thereon to be examined by its engineer, and has caused several samples of the water, some of which have been collected by you, to be analyzed. The results of the analyses show that the water of this source is softer than most of the waters of this region, and is usually clear, nearly colorless and odorless, and otherwise of excellent quality for the purposes of a public water supply. Its watershed contains very few dwelling houses, and the source could probably be protected from danger of sewage pollution at no great expense.

The results of measurements of the flow of this stream made by you during last summer indicate that the yield of this source would be insufficient for the supply of Great Barrington, even in an ordinary summer season; while in a dry season this source, even if used in connection with the East Mountain reservoir, would doubtless be entirely inadequate to supply the quantity of water required by the district.

The yield of Goodale Brook could be considerably increased by the construction of reservoirs upon the stream, but the cost of suitable dams for the storage of sufficient water on this stream to make its yield adequate even for the present requirements of Great Barrington in a dry season would be very large; and, in the opinion of the Board, it is not practicable to develop this source by the construction of storage reservoirs of such capacity that it will be capable of supplying all the requirements of the fire district for any considerable time in the future, even if used in connection with the present East Mountain source. It appears that a pipe line seven

miles in length would be necessary to convey water from Goodale Brook to the fire district; and, considering all the circumstances, the Board does not advise the construction of works for taking a supply from this source.

There are other sources in the neighborhood of Goodale Brook, including Fenton Brook, so called, and Prospect Lake, from which water of good quality for domestic purposes can be obtained; and it is possible that a sufficient supply of water for the fire district for a long time in the future could be obtained by the construction of reservoirs and the development of these sources; but pumping would probably be necessary in order to supply the highest parts of the fire district, and the cost of a supply from these sources would very probably be excessive.

The Board has also made examinations of the water of Harmon, or Rawson, Brook, so called, in the town of Monterey, which you have already investigated, with a view to its use as a source of water supply for the Great Barrington fire district, though this source is not mentioned in your application. The results of analyses of several samples of water from this stream and its principal tributaries show that the water is of good quality for the purposes of a public water supply, though somewhat colored by contact with vegetable matter and somewhat harder than the water of Goodale Brook. It is practicable, on account of the large size and high elevation of the water-shed of Harmon Brook, to obtain therefrom an ample supply of water for Great Barrington, which could be delivered by gravity to all parts of the fire district. A small storage reservoir on this stream or one of its tributaries will doubtless be sufficient to secure an ample supply of water from this source at present; and your investigations show that, when necessary, a large storage reservoir can be constructed on this stream a little over half a mile below the junction of its two principal tributaries, which would make it practicable to obtain from this source a quantity of water far in excess of that now required for the supply of the Great Barrington fire district.

In the opinion of the Board, Harmon Brook is the best available source from which it is practicable to obtain an adequate water supply for the Great Barrington fire district by gravity that has thus far been considered. Notwithstanding that the pipe line required to convey water from this source to Great Barrington would be one and one-half miles longer than a pipe line to Goodale Brook, the cost of the works is likely to be considerably less than the cost of the works that would be necessary to secure an adequate supply from Goodale Brook, taking probable future requirements into account.

It is understood that other possible sources of water supply have been investigated by the district, but the results of these investigations have not been submitted to the Board. If you desire further advice as to any other possible sources of water supply for the fire district, the Board will, upon application, cause them to be examined and will advise you concerning them.

AUG. 6, 1903.

To the Committee on Water Supply of the Great Barrington Fire District.

GENTLEMEN: — The State Board of Health received from you, on May 9, 1903, an application, under the provisions of chapter 75, section 117, of the Revised Laws of Massachusetts, for advice with reference to certain proposed sources of water supply for the Great Barrington fire district, including Kilbourne Brook, Mangion Brook, Snyder Brook, Soda Creek, Goodale Brook, Fenton Brook and Harmon Brook, and ground water from the valley of the Green River.

After investigation, you have found that the yield of the first four sources mentioned would be too small to make them worthy of consideration as sources of water supply for the Great Barrington fire district, and you have subsequently presented two schemes of water supply for the advice of the Board, as follows: —

1. A gravity system from Goodale and Fenton brooks and the present East Mountain reservoir, enlarging the latter by raising the dam about two feet. Pumping would be necessary to supply the high-service district in connection with this plan.

2. A ground-water supply from the valley of the Green River, which you propose to pump by water power, to be developed by the construction of a large storage reservoir in this valley. It is proposed to use the supply in connection with the present East Mountain reservoir, raising the latter two feet, and the present Berkshire Heights distributing reservoir.

In response to your application, the Board has caused the various sources to be examined by its engineer and samples of their waters to be analyzed, and has considered the information submitted at various times with reference to a water supply for the Great Barrington fire district.

An adequate supply of water for the present needs of the Great Barrington fire district could probably be obtained by the use of Goodale and Fenton brooks in combination with the present East Mountain reservoir, as proposed; but to secure an adequate supply from these sources it will be necessary to build reservoirs upon the Goodale or Fenton brooks, and there are no sites on these streams where reservoirs of considerable storage capacity could be constructed except at large expense. Moreover, a pipe line about seven miles in length would be necessary to convey the water from those brooks to the fire district, and, should the fire district increase considerably in population, the sources could not readily be supplemented, if it should become necessary.

The plan proposed by a previous committee for supplying the Great Barrington fire district with water from Harmon Brook in Monterey would, in the opinion of the Board, probably be less expensive, considering all conditions, than the plan of supplying the district from Goodale and Fenton brooks and the East Mountain reservoir, and an ample supply would be available; but the water of Harmon Brook is considerably harder than that

of Goodale and Fenton brooks or the East Mountain reservoir, and would to that extent be less desirable for some purposes than the water of those sources.

The investigations relative to obtaining a ground-water supply from the valley of the Green River have not shown that it is practicable to obtain an adequate supply of good water from the ground in this valley. Judging from the character of the surface soil in the valley of the Green River, there are considerable areas of porous soil from which it may be practicable to obtain water freely by means of wells or other suitable works; but it is impossible to determine, without suitable tests, whether it will be practicable to obtain an adequate supply of water for the Great Barrington fire district from the ground in this valley, or the probable quality of the ground water. It is likely also that the cost of works for supplying the district with ground water from this valley would be greater than the preliminary investigations indicate.

Considering all the circumstances, the Board would advise the Great Barrington fire district to cause investigations to be made, with the assistance of an engineer of experience in matters relating to the development of ground-water supplies, to determine the practicability of obtaining an adequate supply of water from the ground in the valley of the Green River, and the probable cost of a supply from this source. If such a supply should be used, it would be necessary to keep it from exposure to light from the time it is drawn from the ground until it is delivered to the consumer.

The Board would also advise that you have the plans for obtaining a supply from Harmon Brook in Monterey revised and given further careful consideration, in order that the estimated cost of a supply from this source may be compared directly with an estimate of the cost of a supply from works in the valley of Green River, should it be found practicable to obtain a supply of water from the latter place. The Board will, upon application, assist you in such investigations by making such analyses of the water as may be necessary, and will give you further advice in the matter when the results of further investigations have been presented.

HINGHAM.

APRIL 2, 1903.

To the Hingham Water Company, Hingham, Mass., MR. EBED L. RIPLEY, *President.*

GENTLEMEN: — The State Board of Health received from you, on February 10, an application for advice with reference to improving and increasing the water supply of Hingham and Hull, containing the following outline of plans which you have under consideration: —

Three plans are under consideration: First, removing the mud from the upper arm of Fulling Mill Pond over an area of approximately four acres, building a dam between this arm and the remainder of the pond in such a manner that any seepage of water from the latter shall be excluded, except after filtration through

a considerable distance in the ground, and using this basin as a collecting reservoir for the flow of Fulling Mill Brook and the springs in its vicinity; second, laying an open joint, vitrified pipe, surrounded by clean gravel or broken stone, in a trench around the upper end of the pond, for the purpose of collecting the flow of the ground water before it reaches the latter, the bottom of this trench to be from 10 to 12 feet below the surface of the water in the pond, the trench to be carried around the pond towards South Pleasant Street and there connected with a dug well or filter-gallery in Shute's Meadow; third, a driven well system which will cover practically the same ground as the trench last described, and may be extended further if necessary.

The object of either of these plans is to collect in the most feasible way the flow of the ground water around Fulling Mill Pond, and also to collect the flow from the system of filtration which may be installed at the head of Fulling Mill Pond for the purpose of treating the water of Accord Brook, and also treating the water of Accord Pond when such treatment is necessary.

Subsequently, on March 2, plans were submitted showing outlines of the proposed works under each of the plans considered, and a report was also submitted by your engineer, together with a description of the results of examinations of the soil near Fulling Mill Pond by means of test wells.

The Board has carefully considered the plans and the results of the investigations thus far made upon the development of a ground-water supply for Hingham and Hull in the neighborhood of Fulling Mill Pond.

The first plan presented, which provides for removing the mud from the bottom of the southerly arm of Fulling Mill Pond and using the open basin thus created for the collection and storage of ground water, is, in the opinion of the Board, a very objectionable one, since experience has shown conclusively that ground waters deteriorate rapidly when exposed to light in open basins, and become affected by the presence of organisms which impart to the water a disagreeable taste and odor.

A modification of this plan is mentioned in the report of your engineer. It provides for the construction of a covered reservoir in this arm of Fulling Mill Pond, instead of an open basin, which would obviate the danger of deterioration of the water from organic matters; but it is estimated that the cost of such a reservoir and of suitable works for the collection of ground water near Fulling Mill Pond would be greater than the cost of works under your second plan, and therefore is not recommended.

The second plan mentioned in your application, which provides for a pipe conduit around the southerly side of Fulling Mill Pond and a well in Shute's Meadow, into which the pipe will discharge the ground water collected by it, is, in general, in the opinion of the Board, a satisfactory method of collecting the ground water in this region. The proposed well, as indicated on the plan, is located about 100 feet from the present open filter-gallery, on the opposite side of a gravel ridge, and a little less than 600 feet from the point where the brook from Shute's Meadow crosses South Pleasant Street. The pipe for collecting ground water into this

well, as shown on the plan, extends across the gravel ridge to the filter-gallery and thence around the southerly end of Fulling Mill Pond, in some places close to the edge of the pond, and terminates near the brook, which at present forms the main feeder of the pond, about 300 feet above its present outlet. If this pipe should be laid as proposed, and in a thorough manner, so that water could freely find its way into the pipe, and all sand and similar matters tending to clog the pipe should be kept out, this pipe would doubtless collect much of the ground water now finding its way into Fulling Mill Pond and the brook which enters it.

The third plan mentioned in the application is a driven well system, covering practically the same ground as the pipe in the second plan, which can be extended further if necessary. The tests that have been made show that, on account of the character of the soil, which consists in many places of boulders of considerable size, it would be difficult to put in a well system which would collect as large a proportion of the ground water flowing toward the pond as the conduit proposed. It may be found desirable, in some places where the conduit would pass through fine material, to drive wells to reach coarser material beneath; and wells could be put in wherever found desirable and practicable, and connected with the conduit.

It is important that the trench for collecting ground water be placed at a sufficient distance from the pond, to avoid danger that imperfectly filtered water may find its way into the collecting pipe, and for this reason the pipe should not be laid beneath the pond or nearer than 50 feet from the shore; and if it is necessary to lay this pipe close to or under the pond or under a peaty deposit of any considerable depth in a swamp, the pipe should be laid with tight joints. Care should also be taken in laying the pipe to prevent the entrance of water containing iron, or any water which appears to be objectionable.

A considerable quantity of ground water, apparently coming from Fulling Mill Pond, now flows off in a stream through Shute's Meadow, and the ground water from the southerly side of the meadow also finds an outlet through this stream. It would be desirable either to place the well farther down in Shute's Meadow, or to provide a trench to intercept this water and convey it into the collecting well. It may be found desirable also to extend the trench farther up the valley of the main feeder of Fulling Mill Brook, and possibly lay other trenches to the main collector when the filtration of water from Accord Brook or Accord Pond upon the gravel beds in this region shall be begun; and provision should be made for such extensions so far as is practicable at the present time.

The plans submitted do not show the proposed method of treating the water of Accord Brook or Accord Pond, the details of which are presumably not yet prepared.

If the basin at the present pumping station is to be used in connection with the proposed plan of supplying ground water, it should be covered so as to exclude the light.

HOLYOKE.

APRIL 2, 1903.

To the Board of Health of the City of Holyoke, FRANK A. WOODS, M.D., *Secretary*.

GENTLEMEN: — In response to your request received March 9 for an examination of the water of a well upon the premises of the National Blank Book Company and advice as to the quality of this water for drinking purposes, the Board has caused the well and its surroundings to be examined by one of its engineers, and a sample of the water to be analyzed.

The results of the analysis show that this water resembles very closely the water of other wells similarly situated in Holyoke. At the time it was examined it was clear, colorless and odorless, and, while it had evidently at some time been considerably polluted by sewage, it had subsequently been very thoroughly purified before entering the well. The water is much harder than that of the city supply. The analysis does not indicate that the water of the well, at the time this examination was made, was unsafe to use for drinking purposes; but its hardness is objectionable, and, as in the case of the other wells similarly located, changes in the height of ground water and the circumstances attending the pollution of the well may at any time render the water unsafe for drinking, and the Board cannot recommend its continued use for drinking purposes.

MAY 7, 1903.

To the Board of Water Commissioners of the City of Holyoke, Mr. A. E. PICKUP, *Registrar*.

GENTLEMEN: — In response to your communication received April 18, relative to the possible necessity of closing the road around Whiting Street reservoir to prevent danger of pollution of the water of the reservoir, the Board has caused an examination of the locality to be made by its engineer, and has considered the information which you have furnished concerning the use of the road.

It appears that certain changes are now being made in the location of buildings in the park used by the public near the north-easterly end of the Whiting Street reservoir, and that when these changes have been completed the water-shed of the reservoir will be free from dwelling houses or other buildings from which polluting matter might find its way into the reservoir or any of its feeders.

It is not desirable that any portion of Whiting Street reservoir or its water-shed should be used as a pleasure resort by considerable numbers of people, and access to the pond should be prevented; but the use of the roadway about the pond as at present for pleasure driving is not, in the opinion of the Board, liable to seriously injure the quality of the water, and it does not appear to be necessary to prevent this use of the road at present.

HULL (FORT REVERE).

APRIL 2, 1903.

To Lieut. R. A. AMADOR, *Contract Surgeon, U. S. A., Fort Revere (Hull)*.

SIR: — In accordance with your request of Jan. 22, 1903, for an examination of a sample of water at Fort Revere in the town of Hull, Mass., and advice as to its suitability for drinking purposes, the Board has caused the well and its surroundings to be examined, and several samples of the water to be analyzed.

The well does not appear to be exposed to danger of sewage pollution at the present time, but the results of the analyses show that the water, though nearly clear and colorless, contains considerable organic matter, and is excessively hard. It also contains a considerable quantity of iron. While there seems to be no reason to conclude, from an examination of the surroundings of the well, that it is being polluted by organic matter that is injurious, it is best, in the opinion of the Board, to avoid the use of water having such an excessive hardness; and, since it appears that water from the public supply of the town of Hull is available for drinking at Fort Revere, the Board would advise that this water be used, and the further use of water from the well for drinking avoided.

HYDE PARK (B. F. STURTEVANT COMPANY).

OCT. 9, 1903.

To the B. F. Sturtevant Company, Jamaica Plain Station, Boston, Mass.

GENTLEMEN: — The State Board of Health received from you, on Aug. 28, 1903, an application for advice as to the practicability of obtaining water for drinking and other domestic purposes from wells which you were then driving near your new manufacturing plant at Hyde Park, and has caused the locality to be examined by one of its engineers, and samples of the water from the sources indicated by you to be analyzed.

One of these sources is a well 8 inches in diameter and 500 feet deep, sunk through 50 feet of gravel and 450 feet of rock; another is a well 2 inches in diameter and 25 feet deep, located not far from the 8-inch well; and the third is an excavation in a neighboring street.

The results of analyses of water from these three sources show that water from the trench in Readville Street is greatly polluted by sewage; and the water from the 2-inch pipe well is also polluted, but to a less extent. The chemical analysis of the water of the deep well does not show evidence of serious pollution by sewage, but the number of bacteria found in the water of a sample from this well after four days' pumping was high, indicating that it is affected by pollution from some source.

The experience with waters drawn from the ground in thickly settled localities, such as that in which your works are situated in Hyde Park, has shown that such waters are nearly always affected by sewage and other polluting matters discharging upon or into the ground from dwelling houses

and other buildings; and, while it is possible that water might be obtained from the ground at some point in the immediate neighborhood of your works which would not cause injury to the health of those who might use it for drinking, the population in the neighborhood seems likely to increase rapidly, and such waters would be likely to deteriorate; and, in the opinion of the Board, it is not advisable for you to attempt to obtain a supply of water for drinking from the ground in the immediate neighborhood of your works.

Water such as that obtained from the tubular wells thus far put in can be purified by filtration through sand, so that it will be safe for drinking and suitable for other uses in your factory; and the Board would advise you to make investigations with a view to obtaining a supply of water from the ground at your works which can be made satisfactory by filtration, and that in your investigations you secure the assistance of an engineer of experience in matters relating to water supply.

Lawrence.

June 15, 1903.

To the Lawrence Water Board, Lawrence, Mass.

Gentlemen: — The State Board of Health received from you, on June 5, an application requesting approval by the Board of plans of a proposed new filter for the purification of the water supply of the city of Lawrence, to be constructed on the northerly bank of the Merrimack River, west of and adjacent to the present filter.

The plans provide for a covered filter, .75 of an acre in area, to be constructed with concrete masonry, partly on the bank of the river and partly within the present bed of the stream; and soundings showing the depth of mud are submitted, though the character of the soil at greater depths is not shown. The filter is to be thoroughly underdrained by tile pipes, broken stone and gravel; and the filtering material is shown upon the plan to be 4 feet in depth of sand, of the size indicated by the following provision in your specifications: —

Sec 103. The diameters of the sand grains shall be computed as the diameters of spheres of equal volumes.

The grains shall have the following diameters: not more than one-quarter (¼) of one per cent. by weight shall be less than thirteen hundredths (.13) of a millimeter; not more than six (6) per cent. less than twenty-six (.26) hundredths of a millimeter. At least six (6) per cent. by weight shall be less than thirty-four (.34) hundredths of a millimeter; at least seventy (70) per cent. less than eighty-three (.83) and at least ninety (90) per cent. less than two and one-tenth (2.1) millimeters. No particles shall be more than five (5) millimeters in diameter and the sand shall be passed through screens or sieves of such mesh as to stop all such particles, and no screen or sieve shall be used containing at any point holes or passages allowing grains larger than the above to pass.

Water is to be applied to and effluent drawn from the filter by means of pipes passing through an operating house, so called, at the north-easterly corner of the filter nearest the pumping station, which will contain devices for regulating the supply of water to the filter and the rate of filtration. The water supplied to the filter will be drawn from the present inlet from the Merrimack River through a 24-inch pipe, which will discharge into a chamber in the operating house, and thence rise and pass over weirs in the sides of this chamber to the surface of the filter. The filtered water will be collected by the underdrains into a main drain, passing through the bottom of the chamber containing the unfiltered water to an adjacent filtered water chamber, from which it will flow to the pump well at the pumping station. A gate is shown on the filtered water conduit in the unfiltered water chamber, by means of which the flow of filtered water can be shut off if necessary.

It is understood that the filter is to be operated continuously at a rate of about 3,000,000 gallons per acre per day, and it is thought that a higher rate of operation may be found practicable.

You also give the following outline of further plans for enlarging the water supply of the city: —

With the new filter in operation it is believed that sufficient water for the immediate needs of the city will be obtained and shortly the present filter can be covered and have its capacity increased, by sections if necessary, and somewhat on the lines proposed for the new filter, so as to furnish a still greater supply. Later, when the necessity demands, another filter can be built directly west of the proposed new one.

The Board has carefully considered your application and the plans submitted therewith, and the probable results to be obtained from the operation of the proposed new filter in connection with your present works.

An additional filter is urgently needed, and it is very important, in the opinion of the Board, that the construction of a new filter be pushed as rapidly as possible, in order that additional filter capacity may be available before the beginning of the next winter. The proposed new filter will furnish, in connection with the present filter, a sufficient supply of water for present requirements, but it is important that the work of covering the present filter be carried out as soon as possible.

Economy in the operation of the works requires that the new filter should be located near the present filter, as you propose, and the general plan of constructing a covered masonry filter upon which river water can be delivered by gravity and from which the effluent will be discharged into your present pump well is the best one to adopt; but, in the opinion of the Board, certain details of construction of the proposed filter should be modified, in order to secure a well-purified water, and prevent possible danger that unfiltered water may mingle with the filtered water.

The specifications for the sand to be used as filtering material do not show definitely the effective size of the sand likely to be placed in the filter, and it seems possible that, under these specifications, a sand might be used which would be too coarse to insure safe results in the purification of the water.

The Board would advise that you make provision for securing sand for use in this filter which will have an effective size not greater than .28 of a millimeter nor less than .24 of a millimeter; that is, sand of which at least 10 per cent. shall have grains of a size no greater than .28 of a millimeter nor less than .24 of a millimeter.

The filter, as designed, is to be filled with water from below, and no provision is made for distributing water over the surface, when filling, without disturbing the sand.

The river water is becoming more polluted every year, and has now reached a stage when at certain times in summer water passing the present filter has its absorbed oxygen very nearly all taken from it by the organic impurities before reaching the underdrains. Very soon it will be necessary to either filter this water intermittently, or to pump it and allow it to fall through the air in broken streams, in order to aerate it and supply sufficient oxygen to burn up the organic impurities before it gets through the filter. The better method here will be to provide for intermittent filtration, by which, during such seasons of warm weather, water may be drawn out of the filter daily and air allowed to enter the sand, and water being applied to the surface will mingle with this air in its passage through the filter. This process will not allow of filling the filter from below, which would push the air out of the sand; hence provision should be made for distributing water over the surface of the filter when empty without disturbing the sand.

Another objection to filling the filter from the underdrains is the danger of injuring the efficiency of the filter by backing the water up too fast, and forcing the air out so rapidly as to disturb the upper layers of sand and allow bacteria to pass through the filter in increased numbers.

The plans represent a depth of sand of 4 feet above the gravel surrounding the underdrains, and from 4½ to 5 feet elsewhere; but the specifications provide for the contractors furnishing only an average depth of 3½ feet of filter sand. This amount of sand would be entirely inadequate to provide efficient filtration. In the opinion of the Board, there should be as much as 4½ feet of filter sand above the gravel of the underdrains.

An objection to the present arrangement for delivering water upon the filter and conveying the filtered water therefrom is that the main pipe from the underdrains of the filter will pass through a chamber containing unfiltered water, and that a controlling gate is located on this filtered water conduit in the unfiltered water chamber. With this arrangement, if there should be a leak in the gate or a crack in the pipe, unfiltered water might leak into the pipe containing the filtered water.

A further objection to the present plan is that the chamber through which the unfiltered water is to pass on its way to the filter is adjacent to the effluent chamber containing filtered water on its way to the pump well, the chambers being separated only by a concrete wall 18 inches thick; and there will be danger that unfiltered water may find its way through cracks or interstices in the masonry into the filtered water in this chamber.

It is important, in the opinion of the Board, that provision be made for preventing any possibility that any of the polluted river water, before filtration, may mingle with the filtered water, even in very small quantities; and to insure safety in this matter, the filtered water should not be conveyed through or near the chamber containing unfiltered water, and the chambers containing filtered and unfiltered water should be separated, with several feet of earth between them.

The Board would advise that the rate of filtration be not more than 2,500,000 gallons per acre daily, and that, as the water of the river becomes more polluted, this rate should be decreased.

The Board has not considered, and does not regard itself called upon to consider, the ordinary engineering questions of stability of the foundations, walls or roof, or the efficiency of the specifications in regard to these matters of construction, but limits its consideration to matters affecting the efficiency of the filter in protecting the health of the community, and for this purpose finds the changes indicated should be made in the design before giving its approval.

DEC. 3, 1903.

To the Lawrence Water Board, Lawrence, Mass.

GENTLEMEN: — Plans of a proposed filter for the purification of the water supply of the city of Lawrence were submitted by you for the approval of this Board on June 5, 1903; and on June 15, 1903, after considering the proposed plans so far as they affected the efficiency of the filter in protecting the health of the community, the Board suggested certain changes in the design of the filter before giving its approval. One of these suggested changes related to the sand to be used as filtering material; and through your engineer the Board received, on November 18, the following copy of your proposed new specifications for sand to be used in the filter: —

SECTION 103. The diameters of the sand grains shall be computed as the diameters of spheres of equal volumes.

The grains shall have the following diameters: not more than one (1) per cent. of weight shall be less than thirteen one-hundredths (.13) of a millimeter; not more than ten (10) per cent. by weight shall be less than twenty-two one-hundredths (.22) of a millimeter. At least eight (8) per cent. by weight shall be less than twenty-six one-hundredths (26) of a millimeter. At least seventy (70) per cent. by weight shall be less than eighty-three one-hundredths (.83) of a millimeter and at least ninety (90) per cent. by weight shall be less than two

and one-tenth (2.1) millimeters. No particles shall be more than fifteen (15) millimeters in diameter and the sand shall be such that all will pass through screens or sieves having meshes of holes no larger than fifteen (15) millimeters.

It is also stated that the above-specified requirements will produce sand whose effective size will be between .22 and .28 of a millimeter.

The plans have now been modified so that the water from the river can be distributed over the surface of the filter when filling without disturbing the sand. This is very important, since the water of the river is becoming more polluted every year; and there are certain times in summer when the water passing the present filter has its dissolved oxygen very nearly all taken up by the organic impurities of the water before reaching the underdrains. It may soon be necessary, as indicated by the Board in its previous communication of June 15, either to filter the water intermittently, or to aerate it thoroughly by pumping and allowing it to fall through the air in broken streams before it is applied to the filter. With the provision for intermittent filtration, the water may be drawn out of the filter daily, and air allowed to enter the sand; and the water, being applied to the surface of the sand, will mingle with this air in its passage through the filter, which is the better method of securing the efficient purification of this water. There is a serious objection to filling the filter from the underdrains, on account of the danger of injuring the efficiency of the filter by backing the water up too fast, and forcing the air out of the sand so rapidly as to disturb the upper layers of sand, and allow bacteria to pass through the filter in increased numbers.

The plans now presented show a depth of 4½ feet of sand above the gravel surrounding the underdrains, as advised in the previous communication of the Board. It is important that this depth be not reduced materially by repeated scrapings without restoring the sand. The Board would advise that the filters be maintained as nearly as possible to the full depth of the sand at all times, and that the surface be not lowered so that the depth at any time will be more than 4 inches less than the full 4½ feet.

The proposed changes in the arrangement of delivering the water to the filter and for drawing the filtered water to the pumping station will avoid the objections to the former arrangement, by which the chambers containing the filtered and unfiltered water were adjacent, and the water after filtration passed in a pipe through the chamber containing unfiltered water.

The Board would advise that the proposed new filter be operated at a rate of not more than 2,500,000 gallons per acre daily, and that, as the water of the river becomes more polluted, this rate be decreased.

As stated in the previous communication already referred to, the Board has not considered, and does not regard itself as called upon to consider, the ordinary engineering questions of stability of the walls, foundation or roof, or the efficiency of the specifications in regard to these matters of

construction, but limits its consideration to matters affecting the efficiency of the filter in protecting the health of the community. If the filter is built in a substantial manner, in general accordance with the plans now submitted, and is operated in accordance with the suggestions herein contained, an efficiently purified water can be obtained for the supply of the city of Lawrence; and, with the limitations indicated, the Board approves the plans as now presented.

These plans bear the following titles: —

Sheet No. 1. — (Blue Print.) "Lawrence, Mass., Water Works. Covered Slow Sand Filter. General Plan, Cross Sections and Profile of Drain Line. Scale, 1 inch = 20 feet. Chapin and Knowles, Civil and Consulting Engineers."

Note. — Changes in red ink are shown on this sheet.

Supplementary Sheet No. 1. — (Blue Print.) "Lawrence, Mass., Water Works. Covered Slow Sand Filter. Changes in Details of Inlet and Outlet Mains. Scales as Shown. Chapin and Knowles, Civil and Consulting Engineers."

Sheet No. 2. — (Blue Print.) "Lawrence, Mass., Water Works. Covered Slow Sand Filter. Plan, Cross Sections, Underdrains and Profiles of Pipe Lines. Scale, 1 inch = 10 feet. Chapin and Knowles, Civil and Consulting Engineers."

Note. — Changes in red ink are shown on this sheet.

Supplementary Sheet No. 2. — (Blue Print.) "Lawrence, Mass., Water Works. Covered Slow Sand Filter. Revised Arrangement of Regulating Apparatus in Pump Well. Scales as Shown. Chapin and Knowles, Civil and Consulting Engineers."

Sheet No. 6. — (Blue Print.) "Lawrence, Mass., Water Works. Covered Slow Sand Filter. Details of Cast Iron Pipe and Inlet Controlling Valve. Scales as Shown. Chapin and Knowles, Civil and Consulting Engineers."

Note. — Changes in red ink are shown on this sheet.

LAWRENCE (EVERETT MILLS).

NOV. 5, 1903.

To Mr. J. I. MILLIKEN, *Agent, Everett Mills, Lawrence, Mass.*

DEAR SIR: — In response to your request, received September 9, for advice as to the quality of the water of a well in your mill yard, used as a source of drinking water by the operatives in the mills, the Board has caused the well and its surroundings to be examined and samples of the water to be analyzed.

The results of the analyses show that much of the water entering this well has been highly polluted by sewage, and subsequently quite well purified in its passage through the ground before entering the well, so that the water, as shown by these analyses, was colorless, tasteless and odorless; but the results of bacterial examinations show the presence of a much larger number of bacteria than is found in good ground waters, and bacteria characteristic of sewage have been found to be present.

Considering these circumstances, the Board would advise that the further use of water from this well be prevented.

Lincoln.

Under the provisions of section 113 of chapter 75 of the Revised Laws, rules and regulations were made by the Board on Sept. 3, 1903, for preventing the pollution and securing the sanitary protection of the waters of Sandy Pond and its tributaries, used by the town of Lincoln as a source of water supply.

Littleton.

Feb. 16, 1903.

To Messrs. Edwin A. Cox and Frank B. Priest, *Littleton, Mass.*

Gentlemen: — The State Board of Health received from you, on January 27, an application relative to a proposed water supply for the town of Littleton, in which you state that the proposed source of supply is Long Pond in that town, water from which is to be taken near the west side of the pond and pumped for the supply of the main village; and in response to this application the Board has caused the pond and its surroundings to be examined by its engineer as thoroughly as is practicable at this season of the year, and a sample of the water to be analyzed.

The results of the analyses and the examination of the pond show that the water is quite highly colored, which is due probably in part to the contact of the water with vegetable matter in the swamps near the pond and possibly also to organic matter on the bottom of the pond. The watershed of the pond contains but few buildings, and, while there is a picnic ground located near its easterly shore, the source could probably be protected from serious danger of sewage pollution without special difficulty; but the water is objectionable for water supply purposes on account of its high color, and it is likely that the waters of this source would be affected at times by disagreeable tastes and odors, due to microscopic organisms which ordinarily appear in considerable numbers, especially during the warmer portion of the year, in the waters of ponds of this character.

The conditions in the valley of Beaver Brook, north-west of the village of Littleton, appear to be favorable for obtaining a supply of water for the village from the ground by means of wells or other suitable works, so far as can be judged from surface indications; and a good ground water, on account of the freedom of such water from color, taste and odor, would be far preferable for domestic purposes to the water of Long Pond. The Board would, therefore, advise that you have an investigation made as to the practicability of obtaining a supply of ground water from some suitable source. The Board will assist you in any further investigations which you may decide to make, by making the necessary analyses of samples of water, and will give you further advice when the results of further investigations are available.

LOWELL.

AUG. 26, 1903.

To the Lowell Water Board, Lowell, Mass.

GENTLEMEN: — In response to your request of July 28 for bacterial examinations of the water supply of the city of Lowell, the Board caused samples to be collected from various parts of the city on July 29 and again on July 31, and sends you herewith the results.

The average number of bacteria found in different parts of the city on July 29 was 17, which is nearly the same as the number found at the force main at the Boulevard wells, indicating no added pollution at this time. This number is smaller than the average found in other driven-well supplies throughout the State.

Upon examining these bacteria to learn if Bacillus Coli, which is regarded as indicative of pollution by sewage, was present, none were found in any of the samples when the usual amount of one cubic centimeter was examined; but, upon examining one hundred times this amount, this species was indicated in two samples, viz., one taken from a store in Pawtucketville and one taken from Walker Street. In both these cases the whole number of bacteria was unusually small, averaging but ten, indicating a small degree of pollution.

Another series of samples taken on July 31 gave somewhat higher numbers of bacteria present, but no greater increase than might be expected from the temporary effect of the flushing out of the city mains on July 29, after the collection of the first series. By this flushing and the subsequent filling the sediment remaining in the mains was probably stirred up, and the bacteria in this sediment and upon the sides of the pipes were detached.

The number of bacteria in all of these samples averaged as low as in other driven-well supplies in the State, but the presence of Bacillus Coli, even in small numbers, was an unusual occurrence. With the first four samples of the second series all of the bacteria in 1,000 cubic centimeters were also examined, with no indication of Bacillus Coli.

LOWELL (LOWELL TEXTILE SCHOOL).

OCT. 1, 1903.

To the Trustees of the Lowell Textile School, Lowell, Mass., Mr. JAMES T. SMITH, *Clerk*.

GENTLEMEN: — The State Board of Health received from you, on September 12, a communication requesting an examination of the water of certain springs located near the Lowell Textile School, to determine whether these waters are suitable for drinking; and in response to this request the Board has caused the springs indicated by you and their surroundings to be examined and samples of their waters to be analyzed.

The results of the analyses show that the waters of both sources have at some time been greatly polluted but subsequently well purified in their pas-

sage through the ground to the place from which the samples were collected; and, in the state in which they were found at the time these examinations were made, these waters would probably not be injurious to the health of those who might use them for drinking. The danger in the use of such sources is that the polluting matters which affect the water may not at all times be completely purified before the water reaches the spring, and the Board does not consider it advisable to use the waters of these springs for drinking purposes.

Lynn.

Nov. 5, 1903.

To the Lynn Water Board, Lynn, Mass., Mr. William B. Littlefield, *President.*

Gentlemen: — The State Board of Health received from you, on April 16, the following communication, requesting the Board to make rules and regulations under the provisions of chapter 75, section 113, of the Revised Laws: —

There are several sources of pollution upon brooks forming a part of the water supply of the city of Lynn or tributaries thereto.

The public water board of the city of Lynn desires to have the said source of pollution removed, and to that end hereby requests your Honorable Board to enact rules and regulations, as provided in Revised Laws, chapter 75, section 113.

We beg leave to say that the rules and regulations prescribed by your Board for the protection of the waters of Stony Brook reservoir, for the city of Cambridge, would be very satisfactory to the city of Lynn.

In response to this application, the Board caused the sources of water supply of the city of Lynn to be examined. As a result of this examination, it was found that the water supply of Lynn was at that time being drawn from the reservoirs known as Breed's Pond, Birch Pond, Glen Lewis Pond, Walden Pond and Hawkes Pond at different times, and that there was a connection by which water could be drawn from the Saugus River into Hawkes Pond and thence into Birch Pond through a conduit leading from the Saugus River a short distance above the Wakefield branch of the Eastern Division of the Boston & Maine Railroad at Montrose. The water-shed of the Saugus River above this point included, at the time this examination was made, nearly all of the thickly settled portions of the town of Reading and much of the thickly settled portion of the town of Wakefield; and the aggregate population on the water-shed is a very large one, amounting to approximately 766 persons per square mile.

In the annual report of your board, dated Dec. 1, 1902, the following statement appears: —

Our Source of Supply.

Our present system comprises: —

Ponds.	Acres.	Capacity, in Gallons.
Breed's,	54.85	262,563,340
Birch,	82.00	381,062,901
Glen Lewis,	36.00	120,475,126
Hawkes,	75.00	300,000,000
Walden,	128.00	403,163,826
A total storage of	-	1,467,265,193

In connection with these sources we have a conduit from Saugus River to Hawkes Pond, having a daily capacity for delivering about 30,000,000 gallons. The water-shed from which the city has a right to take the water which contributes to this supply contains less than 50 inhabitants to the square mile, and is absolutely free from all direct sewage contamination.

In view of this statement, further information as to the sources of supply of the city of Lynn was sought from your board; and subsequently, on Oct. 8, 1903, a communication was addressed to your board, requesting information as to the sources of water supply actually used for the supply of the city of Lynn. No reply to this communication has been received, but your superintendent of water works has informed the engineer of this Board that the sources now actually used, and which have been used for many years, are the ponds mentioned above, and the Saugus River above Montrose, including the densely populated areas in Reading and Wakefield.

The Board has caused a careful examination to be made of the water-shed of the Saugus River above the point at which the water is taken for the supply of the city of Lynn, which contains, as already stated, a population of 8,960, or 766 persons per square mile, and samples of the water of several of the streams within this water-shed have been analyzed.

The results of the analyses show that the streams are seriously polluted by sewage. An examination made to locate the sources of pollution has shown several cases of direct sewage pollution, but has failed to discover such a number as would account for the serious pollution of the water of the streams as shown by analysis. The region through which many of these streams flow is densely populated, and it is evident that the pollution of the streams comes from a large number of hidden sources. Considering all of the circumstances, the Board is of the opinion that it is impracticable to protect this source of supply from sewage pollution by any sanitary rules and regulations that it is practicable to enforce. There are other ways of

protecting the purity of the water supply of the city, which would be much more efficient than the attempted enforcement of such rules.

There are portions of the water-shed above Montrose which are comparatively sparsely populated, and from which it appears to be practicable to secure water which would be safe for drinking, if rules for the sanitary protection of the water should be enforced. These areas include the water-sheds of Beaver Brook and Pillings Pond; and, judging from the State map, it may be practicable to extend a conduit from the neighborhood of your present intake on the Saugus River along the north-westerly side of that stream, so as to intercept the waters of these sources; and, if it is necessary to use water from the Saugus River water-shed above Montrose, the water of these portions only should be used, and the polluted waters flowing in the main stream at your present intake should be excluded. It is also possible to purify the water of the river by filtration through sand.

In the opinion of the Board, the use of the Saugus River as a source of water supply as at present constitutes a great danger to the health of the inhabitants of the city of Lynn, and the continued use of this source in its present condition should be discontinued immediately.

Marion (New York, New Haven & Hartford Railroad Company).

June 4, 1903.

To the New York, New Haven & Hartford Railroad Company, Mr. L. B. Bidwell, *District Engineer.*

Gentlemen:— In response to your application for an examination of a well at the railroad station at Marion, Mass., and advice as to its quality for drinking purposes, the Board has caused the well and its surroundings to be examined by one of its engineers and a sample of the water to be analyzed.

At the time this sample was collected, the water of the well may have been affected somewhat by matters falling into it during the construction of the new station; but the results of the analysis show that the water has at some time been greatly polluted by sewage, and not thoroughly purified in its passage through the ground before entering the well; and, in the opinion of the Board, the water of this well is unsafe for drinking.

Marlborough.

Oct. 1, 1903.

To the Marlborough Water Board, Mr. George A. Stacy, *Superintendent.*

Gentlemen:— The State Board of Health received from you, on September 10, a communication stating that you have noticed considerable organic matter near the surface of the water in Lake Williams, and that, while this has appeared to a slight degree in every year at short intervals, its presence has been more marked this year, and you request advice as to a remedy.

MERRIMAC.

AUG. 6, 1903.

To the Committee on Water Supply of the Town of Merrimac.

GENTLEMEN: — The State Board of Health received from you, on June 23, 1903, an application under the provisions of chapter 75, section 117, of the Revised Laws of Massachusetts, for advice with reference to a proposed source of water supply for the town of Merrimac, to be taken from tubular wells to be located about 1,000 feet south of the shore of Kimball's Pond in Merrimac, and near the foot of the plain between the swamp south of the pond and Main Street; and in response to this application the Board has caused the locality to be examined by one of its engineers, and has analyzed samples of water from several test wells at this place.

The results of analyses show that the water of the test wells along the foot of the bluff contains an excessive quantity of iron, which would render the water objectionable for many domestic purposes. Additional test wells have been put in by direction of your committee in the sandy plain south of these wells, and samples of water sent in from these new test wells have recently been analyzed by the Board. Some of the samples from these wells contain a greater quantity of iron than is found in good ground waters; but the results of the tests indicate, on the whole, that water of good quality can be obtained from the ground in this locality by avoiding the places where large quantities of iron are found in the ground water.

Regarding the quantity of water that can be obtained by means of wells or other suitable works at this place, it is not practicable to give a definite opinion, with the information thus far available. The tests show that water can be drawn freely from the wells, and the indications are that it may be practicable to obtain a sufficient quantity of water for the present requirements of Merrimac from the ground at this place.

The Board would advise that, before proceeding with the construction of works for supplying water to the town, you cause a test to be made by pumping from a group of wells in this locality by means of a steam pump for a period of at least two weeks, and at a rate as great as would be required for the supply of Merrimac; and that you cause observations to be made upon the level of the ground water in the vicinity of the wells during and after this test, and samples of the water to be collected for analysis at different intervals while the pumping is in progress, to determine as definitely as practicable the probable quantity and quality of water to be obtained from the ground in this locality. The Board will assist you in this further investigation by making such analyses of samples of water as may be necessary, and will, upon application, give you further advice in this matter when the results of a pumping test are available.

JAN. 7, 1904.

To the Committee on Water Supply of the Town of Merrimac.

GENTLEMEN: — The State Board of Health has considered your application for advice with reference to a proposed water supply for Merrimac, in which you outline your proposed plans as follows: —

It is proposed to develop a ground water supply at "The Plains." Wells have been driven at this place, sixteen of which have been connected together and to a steam pump. A pumping test of two weeks' duration has been made on these wells, and observations were taken during the pumping test on six other wells driven in different locations in the vicinity, but not connected with the pump. In the final plan of construction it is proposed to use the sixteen wells which were connected to the pump, driving others if it is necessary to obtain a sufficient supply.

It is proposed to locate the pumping station at such a point that water can be drawn from Kimball's Pond by suction and pumped upon the land in the vicinity of the wells, with a view of increasing the supply by natural filtration through the ground, if the growth of the town and the consumption of water demand in future a greater supply than that naturally furnished by the wells. This water will be pumped into a stand-pipe, which will be covered to exclude the light.

The location of the wells already driven is shown on a plan accompanying this application.

You have also submitted the records of pumping from the test wells during the pumping test mentioned, and the records of observations of the height of water in the different wells.

The Board has carefully examined the plans and information submitted therewith, and the results of analyses of numerous samples of water collected before and during the pumping test.

The information submitted to the Board shows that water was pumped continuously from the wells at a rate of not less than 300,000 gallons per day for a period of two weeks, and that during this time the water in the ground about the wells lowered less than two feet, and less than a foot in any of the test wells in which measurements were made; and, considering the circumstances, the Board is of the opinion that an adequate supply of water for the present requirements of Merrimac can be obtained from the ground where this test was made.

It is probable that a larger supply could be obtained, if necessary, by extending the wells over a somewhat larger area; though care will be necessary, in locating new wells, to avoid using wells in localities containing an excessive quantity of organic matter or iron. If, in future, on account of the growth of the town or increase in the use of water, a larger supply is found necessary than wells in this locality are capable of furnishing, a larger supply can doubtless be obtained without special difficulty by filtering the water of Kimball's Pond either in the manner proposed in your application or by some other plan.

The quality of the water of the test wells, as shown by the results of analyses of numerous samples collected during the pumping test, is excellent for all the purposes of a public water supply; and, if the water shall be kept from exposure to light until delivered to consumers, as proposed in your plan, its quality should remain satisfactory.

In the opinion of the Board, the information furnished by your recent tests shows that a sufficient supply of good water for the town of Merrimac can be obtained from the ground at the locality in which the recent tests were made, and the Board approves the adoption of this source.

Metropolitan Water District (Slaughter House of A. M. Richards, West Sterling).

FEB. 5, 1903.

To Mr. H. C. Bascom, *Leominster, Mass.*

Dear Sir: — In response to your communication relative to the use of a certain saw mill in West Sterling by Mr. Albert M. Richards as a slaughter house, the Board has caused the premises to be examined by its engineer, and has considered the available information as to the conditions existing at the place in question.

It appears that the building which it is proposed to use as a slaughter house, which is now in a dilapidated condition, was formerly used as a saw mill, and is situated on Rocky Brook, so called, about one mile east of the village of West Sterling. The plan of disposing of the waste matters from slaughtering, as indicated by Mr. Richards, is to discharge the liquid wastes directly into the brook, and to maintain a pig sty beneath the saw mill, where other refuse will be fed to pigs.

In the opinion of the Board, if these premises should be used as a slaughter house, and the wastes disposed of in the manner proposed, the brook would be grossly polluted thereby, and a very serious nuisance created.

Middleborough.

APRIL 2, 1903.

To the Board of Health of the Town of Middleborough.

Gentlemen: — In response to your request of Oct. 28, 1902, for an examination of the drinking water used at Leonard and Barrows' shoe shop in Middleborough, which is drawn from a deep tubular well on the premises, the Board has caused the well and its surroundings to be examined and several samples of the water to be analyzed.

The results of the analyses show that this water is much harder than that of the town supply, and has been at some time greatly polluted by sewage, but subsequently quite well purified in its passage through the ground before entering the well; and, in the state in which it has been found at the time that these examinations were made during the past winter, it is not probable that this water would injure the health of those who might use it for drinking.

The well is located in a densely populated part of Middleborough, and the pollution of the water is evidently caused by sewers or other receptacles for sewage, some of which are located very close to the well. The danger in the use of such a water for drinking purposes is that changes in the height of the ground water or in the circumstances attending its pollution may cause a sudden deterioration in its quality, and render its use unsafe.

Under the circumstances, the Board cannot recommend the use of this water for drinking.

Monson (Hospital for Epileptics).

Feb. 5, 1903.

To Everett Flood, M.D., *Superintendent, Massachusetts Hospital for Epileptics, Palmer, Mass.*

Dear Sir: — In response to your request of January 6 for an examination of the water of West Brook, so called, a former source of water supply for the institution at Monson, which you desire now to use again for domestic purposes, the Board has caused the source to be examined by its engineer and samples of the water to be analyzed.

The results of the analyses show, when compared with the analyses of earlier years, a considerable reduction in the amount of polluting matter entering the water; but an examination of the water-shed shows that the buildings from which this pollution was derived are still in existence and that a part of them are occupied, so that the brook is still exposed to pollution from these places.

You have obtained a supply of water from the town of Monson which is safe for drinking, and otherwise of excellent quality for all domestic purposes.

Considering the circumstances, the Board does not advise the use of water from the west reservoir for drinking or cooking, but would advise that water from the Monson works be supplied exclusively wherever it is likely to be used for drinking or cooking.

Aug. 6, 1903.

To the Trustees of the Hospital for Epileptics at Monson, Everett Flood, M.D., *Superintendent.*

Gentlemen: — In response to your application of June 19 for advice with reference to a proposed system of water supply and a proposed system of sewage disposal for new buildings to accommodate about sixty patients, situated on a hillside west of the present building, the Board has caused the proposed sources of water supply to be examined and samples of their waters to be analyzed, and has caused an examination to be made of the area which it is proposed to use for sewage disposal.

The plan of supplying the new buildings with water provides for taking water from springs on the hillside above the proposed new buildings, and conducting it to the buildings by gravity. The hillside on which these springs are located is uninhabited, and the results of analyses of samples

of water from some of the springs show that it is of good quality for drinking and other domestic purposes; and, since the land about and above these springs is used only for pasturage, the water of these sources can easily be protected from danger of pollution at the present time.

The quantity of water which can be obtained from springs in the region indicated is unlikely, in the opinion of the Board, to be sufficient for the supply of the proposed new buildings in the drier part of an ordinary year; but the springs will probably yield a large quantity of good water, which can be delivered to the buildings at small expense; and, under the circumstances, some saving may perhaps be effected in the cost of the water supply of the institution by utilizing such a quantity of water as may be obtainable from these springs, and taking the remaining quantity of water that may be necessary from the water supply system of the town of Monson, your present source of supply. If, upon further investigation, it shall be found that a saving can be effected in this way, it will be reasonable, in the opinion of the Board, to use the water from the springs, as proposed, provided that the Monson supply be made available for use in emergencies, and at times when the quantity of spring water available is insufficient for the requirements of the buildings.

The plan proposed for the disposal of the sewage of the new buildings provides for purifying it upon filter-beds on the easterly side of the road leading from Monson to Palmer; and, judging from a superficial examination of the ground in this locality, suitable soil can be found here for the purification of the sewage, and the use of land in the place indicated for this purpose would not be objectionable. If, upon examination of the soil, it is not found practicable to build filter-beds at this place at reasonable expense, the sewage can be disposed of upon the present disposal area.

Montague.

May 7, 1903.

To Mr. G. E. Rogers, *Treasurer, Miller's Falls Company, Miller's Falls, Mass.*

Dear Sir: — In response to your communication, received April 27, calling attention to the cottages and summer settlement near Lake Pleasant, from which the water supply of Miller's Falls is drawn, and requesting information as to whether the conditions there may unfavorably affect the quality of the water, the Board has caused the pond and its surroundings to be examined, and has considered the results of analyses of the water of this source taken recently and in past years. The results of the analyses do not show any material change in the quality of the water from year to year for many years.

There are buildings near the lake, from some of which polluting matters may find their way into the water, but the chief danger of injury to the quality of the water is the use of the lake as a pleasure resort by large numbers of people in the summer season; and, to prevent this danger, it

is desirable that rules be made for the protection of the water of the lake, and that there be an inspector at the lake during the summer season to enforce the rules. The attention of the water commissioners of Turner's Falls has been called to this matter.

MAY 7, 1903.

To the Water Commissioners of the Turner's Falls Fire District, Turner's Falls, Mass.

GENTLEMEN: — In response to a request for information as to the conditions existing about Lake Pleasant, your source of water supply, and the possible danger of its pollution from buildings near the lake and from its use as a summer resort, the Board has caused the lake and its surroundings to be examined by one of its engineers.

There are buildings near the lake, from some of which polluting matters may find their way into the lake; but the chief danger of injury to the quality of the water is the use of the lake as a pleasure resort by large numbers of people in the summer season. In order to prevent danger of injury to the quality of the water, the Board would advise that you have rules made for the prevention of the pollution of the lake, and that you make provision for the enforcement of such rules by careful inspection at times when such inspection is necessary.

The Board will provide rules and regulations for the sanitary protection of the lake, under the provisions of section 113 of chapter 75 of the Revised Laws, if you so request.

NANTUCKET.

MARCH 5, 1903.

To the Board of Selectmen of the Town of Nantucket, MR. ROLLIN M. ALLEN, *Secretary.*

GENTLEMEN: — The State Board of Health received from you, on Sept. 4, 1902, a communication requesting an examination of the water supply of the Ocean View House at Siasconset, where several cases of sickness had occurred; and in response to this request the Board has caused an examination to be made of the wells from which the supply of water for the hotel is drawn, and has also caused an investigation to be made as to the cause of the numerous cases of illness among the guests and employees of the hotel during the last summer and autumn.

The Board has been unable to obtain a list of all of the guests at the Ocean View House during the season, since the hotel register could not be found, and a list of only 40 persons who were guests at the hotel in 1902 has been obtained. From these 40 persons information has been obtained relative to only about 200 persons out of the 700 to 800 persons said to have visited the hotel during the summer. The investigations of the Board have shown that there were nearly 30 known cases of typhoid fever during the last summer among the employees and the 200 guests of this hotel concerning whom information has been obtained, many of the cases appearing after the guests had left the hotel late in the summer. It is evident that there may have been many other cases of typhoid fever among those

persons who spent their vacation at this resort, in addition to the large number already known, and the epidemic was one of the most serious which has occurred in this State for many years.

The Board is informed that early in June, when the hotel was opened for the season, one of the first guests was a person who had been ill with typhoid fever, though convalescent at the time of his arrival; and, so far as has been learned, there were two other cases in July, one or two in the early part of August, while in the latter part of August the number increased, and numerous cases appeared among the guests after they had returned to their homes in September. It is thus likely that the various privies, cesspools and drains around the hotel became early infected with the germs of typhoid fever. The earlier cases of typhoid fever do not appear to have been reported to the local board of health, as required by law; and, owing to the fact that the investigation by this Board was not begun until after the close of the hotel for the season, it has been impossible to learn accurately the conditions which prevailed there during the summer. It appears that the cases in the first place were largely confined to the employees of the hotel, and that those sick with the disease there were cared for by other employees, who also worked in the kitchen. Under the circumstances, it is not practicable, from the information that has been collected, to determine in what manner, whether by the water supply or food supply, the epidemic was spread so generally among those living at this hotel.

It appears that the well, which formed the principal source of water supply for the hotel, and which was located on the easterly side of the building, was originally curbed with brick, and was 26 feet in depth, but that this well caved in early last summer, and a supply was afterwards obtained by driving a tubular well about 10 feet below the bottom of the old well. Examinations of the conditions about this well show that a pipe which conveys wastes from the kitchen to a cesspool, located about 150 feet from the well, passes in the neighborhood of the well, and, according to the information furnished the Board, about 10 feet from it. This pipe is said to be made of iron, with lead joints in the neighborhood of the well. Another pipe, conveying sewage to the cesspool referred to, apparently passes within about 20 feet of the well, this drain being of Akron pipe. It is not known whether either of these pipes was affected by the caving in of the well. There is another cesspool, located 63 feet from the well, and at a slightly higher elevation. A privy with the contents exposed is located about 90 feet from the well, upon higher land.

It appears that the water is pumped from the well by a steam pump into the pipes leading to the various parts of the building, and that in connection with this distribution system there is a wooden tank located in a room on the top floor of a building known as the "annex." This tank was found, when examined, to be coverless, and its top was about 6 feet above

the floor of the room. The room in which this tank is located is used as a storeroom, and when examined contained slop pails and a sink, into which slops are apparently turned.

The results of analyses of samples of water from the well from which the supply of water for the hotel was drawn, taken in the early part of September last, show this water to have been greatly polluted by sewage and only partially purified in its passage through the ground, and in much worse condition than in the latter part of September, after the guests had gone, showing direct pollution from the sewage of the premises.

During the early part of the summer, while the new tubular well was being driven in the bottom of the old well, the water supply is said to have been taken from the town pump: and an examination of the water of this well was made at your request in August last, and soon afterward the water of a tubular well near the town pump was also analyzed. The results of these analyses show that the water of both wells had been very greatly polluted by sewage, and not thoroughly purified before entering the wells.

In the opinion of the Board, this hotel should not again be occupied until it has been thoroughly disinfected, and a pure water supply and proper system of sewage disposal provided; and the Board would advise that the further use of the well at this hotel and of the town pump and the tubular well near it be prevented.

In order to determine the condition of other wells in Siasconset, the Board caused samples of water to be collected from those wells from which it was practicable to obtain samples on Sept. 26, 1902, the results of which are sent you herewith. Most of these waters gave evidence of serious pollution by sewage, which is not remarkable, considering the numerous receptacles for sewage scattered all about this village.

In the opinion of the Board, the present conditions as to water supply and sewerage in the village of Siasconset are a constant menace to the health of those who live in or resort to the village; and for the protection of the public health a general water supply from some source of known purity should be immediately provided, and the further use of the present polluted wells be prevented. The conditions appear to be very favorable for obtaining an ample supply of excellent water from the ground close to the village, at a small expense, and it is entirely practicable for the village to secure such a supply before the next summer season, and discontinue the use of the present polluted wells.

A system of sewerage is greatly needed by the village, but until such a system is provided it will be necessary to dispose of the sewage by means of privies and cesspools, as at present. In all cases where such receptacles are used they should be thoroughly covered, and their contents removed and properly disposed of whenever necessary.

MAY 7, 1903.

To the Committee on Water Supply for Siasconset, Nantucket, Mass.

GENTLEMEN:—The State Board of Health has considered your application for advice with reference to a proposed water supply for Siasconset, which you propose to take from tubular wells west of the village, and has caused the locality to be examined by one of its engineers, and samples of water from test wells to be analyzed.

Of the test wells examined, those in the golf grounds west of the village have a decided advantage over the other test wells, in that they are located at a considerably greater distance from the town, and the results of analyses show that the water of these wells is not affected by sewage pollution. In other respects the analyses of the water of these test wells show that this water is of excellent quality for all the purposes of a public water supply.

Regarding the quantity of water which could be obtained from the ground in this region by means of wells, the tests thus far made show that the ground yields water very freely, and the indications are favorable for obtaining an ample quantity of water from a well or tubular wells in the region of these test wells for the supply of Siasconset.

It is important that the construction of works for supplying pure water to Siasconset be carried on as rapidly as possible, to avoid danger from the use of the polluted wells of the village during the coming summer.

NANTUCKET (R. E. BURGESS).

AUG. 6, 1903.

To Mr. R. E. BURGESS, *Siasconset, Mass.*

DEAR SIR:—In response to your request of July 15 for an examination of the water of Shawaukemma Spring, from which you propose to sell water for drinking, the Board has caused the spring and its surroundings to be examined and a sample of its water to be analyzed.

The results of the examination show that the territory about the spring is uninhabited, and the water as it comes from the ground is evidently of good quality for drinking; but the chemical and bacterial analyses of the water show evidences of pollution, probably caused by filling carboys and other receptacles upon the floor of the spring house, from which the waste water flows back into the spring. If this spring should be properly covered and the necessary precautions taken to prevent the pollution of the water in the process of collecting and delivering it to consumers, the Board is of the opinion that water of good quality for drinking could be obtained from this source.

NATICK (E. EDWARDS & SONS).

AUG. 6, 1903.

To Messrs. E. EDWARDS & SONS, *Natick, Mass.*

GENTLEMEN:—In response to your request of July 14 for advice as to the quality of the water of a well in your factory used by the employees of the factory and by the public for drinking, the Board has caused the well

and its surroundings to be examined and a sample of the water to be analyzed.

The results of the analysis show that much of the water entering the well at this time had been at some time greatly polluted by sewage, and had not been completely purified in its passage through the ground before entering the well.

The water of the public supply of Natick is of excellent quality for drinking, and, considering the circumstances, the Board would advise that the further use of water from this well for drinking be discontinued.

Needham.

Sept. 3, 1903.

To the Water Commissioners of the Town of Needham, Messrs. Frederic G. Tuttle, William Carter and George H. Toone.

Gentlemen: — The State Board of Health received from you, on July 11, 1903, an application giving notice of your intention to introduce an additional water supply into the town of Needham, accompanied by plans showing a proposed system of conduits for collecting water from the ground about the Hicks Spring, so called, and a plan of a 6-inch cast-iron conduit from a proposed collecting chamber at the Hicks Spring to your present well No. 1, with details of the proposed works. The plan also indicates a proposed dam on the brook, near your present pumping station. Subsequently, records of measurements of flow of Alder Brook, so called, at Dedham Avenue below the Hicks Spring, were submitted by your engineer.

The Board has caused the proposed source of supply to be examined by its engineer and a sample of the water to be analyzed, and has considered the results of the information available relative to the probable yield of the proposed source and of your present sources of supply.

The results of the analysis of a sample of the water of the stream flowing from the Hicks Spring, so called, indicate that its quality at the present time is not as good as that of your present sources of supply. Moreover, the source is situated very close to the main village of Needham, where the population on territory draining toward the spring is liable to increase rapidly in the future, and affect unfavorably the quality of the water.

The information furnished by your engineer as to the flow of the stream at Dedham Avenue, a point considerably below the place at which it is proposed to locate your collecting works, shows that the yield of this source, even early in the summer, sometimes falls nearly to 100,000 gallons per day, and indicates that in a very dry summer the yield would be much less than that quantity. The proposed system of collecting works is not arranged so that any considerable quantity of water stored in the ground can be made available, and the yield of the proposed source under the plan submitted is likely to be materially less than 100,000 gallons per day in a very dry season. It appears from your report for the year 1902

that the wells from which your present supply is drawn became very low near the end of this year, threatening a shortage of water. The rainfall and flow of streams for the year 1902 was about the average, and it is evident that the present sources are inadequate for the supply of the town even in an ordinarily dry season, and will be entirely insufficient in a very dry year, should the consumption of water continue as at present.

Considering these circumstances, the Board is of the opinion that the proposed works for taking water from the Hicks Spring will not furnish a sufficiently large additional supply of water for the town of Needham to enable that town to obtain from all its sources of supply a sufficient quantity of water for the requirements of the town in a dry season, and would advise the town not to construct the proposed works for taking water from this source.

The Board would advise you to make investigations with a view to obtaining a much larger additional supply of water than can be obtained from the Hicks Spring by means of the proposed works, and would advise that tests be made first in the neighborhood of Charles River, to determine whether an adequate additional supply can be obtained from the ground near this stream which can be used in connection with your present works.

It is understood that the construction of the basin proposed at a previous time, to be located at your pumping station, forms a part of your present plan, and the Board would call your attention to the following advice regarding this source, contained in its communication of June 14, 1899: —

Regarding the plan of constructing a basin near the pumping station, the Board is of the opinion that it is doubtful whether, even if a large proportion of the water collected by the basin in the drier portion of the year should enter the ground and reach the wells, a material increase would be obtained in the yield of the wells; but it is understood that it is desired to construct the basin in part for ornamental purposes, and, since it is not likely that the presence of the proposed basin will affect the quality of the water of the wells as now located, there appears to be no serious objection to the carrying out of this portion of the plan. The basin would not be a proper source from which to draw water directly for supplying the town.

NEWBURYPORT.

APRIL 2, 1903.

To the Board of Water Commissioners of the City of Newburyport.

GENTLEMEN: — The State Board of Health received from you, on Feb. 12, 1903, an application for advice with reference to a proposed additional water supply, containing the following outline of your proposed plans: —

It is proposed to build a dam and create a basin in the valley below Jackman's Spring, this basin or reservoir to be used in the storage of any surplus water flowing into it from Jackman's Spring, or which may be pumped into it from any surplus available at the present sources. In connection with this development of the Jackman Spring, it is proposed to install a pumping station on Artichoke River, and pump the water of that river upon the water-shed of Jackman's

Spring, and treat the same upon natural, intermittent, sand filter-beds, for which a large area is available at this point. The effluent from such filtration will be intercepted by the above-described dam and basin. A pipe will be laid from the basin to the present pumping station, and the additional supply obtained by this plan used in connection with the present sources. It is proposed to limit the size of the basin or reservoir to an area which it would be practicable to cover with a masonry vaulting, if it should become necessary to exclude the light to prevent the growth of organisms in the stored water, which will be largely ground and filtered water.

It is also proposed to connect four 3-inch wells which have been recently driven in the vicinity of the dug wells of the Newburyport water works, and discharge their flow into one of the dug wells. These driven wells are flowing wells, and it is not proposed to pump from them. A settling basin will probably be provided to intercept any fine sand which may flow from these wells.

Plans and a report giving an outline of the proposed new works were subsequently submitted by your engineer.

The Board has caused the locality to be examined by its engineer, and has considered the plans submitted and the information available as to the conditions existing in the neighborhood of your present sources of supply.

The water at present flowing from Jackman Spring, so called, a small basin located in the ravine south of your pumping station, is of excellent quality; but experience has shown very conclusively that such waters deteriorate rapidly when exposed to light, and, unless the proposed basin for the storage of this water shall be covered so as to exclude light, the water is likely to be objectionable on account of the presence of organisms and an offensive taste and odor. By building a covered reservoir in this ravine, the excellent ground water now flowing there can be collected and conveyed to consumers without deterioration.

The water of the Artichoke River, with which you propose to increase the yield of Jackman Spring by discharging the river water upon the sandy land at the upper end of the ravine, is affected by the swamps through which this water flows, and by the organic matter in the reservoir in which it is stored, and is highly colored and contains a large quantity of organic matter. There is no doubt that much of the color and organic matter in this water can be removed by slow filtration through sand, as in the manner now proposed. It cannot be determined definitely, without trial, whether, if this water is discharged upon the sandy lands at the upper end of the ravine, it will flow to the proposed covered reservoir to be located near the foot of the ravine; but the evidence furnished by investigations and observations thus far made indicates that the movement of water discharged upon the lands indicated will be in the direction of the proposed reservoir. If it shall be found that considerable water is lost by percolation in other directions, filter-beds can be constructed, and provision made for insuring the collection of the filtered water.

The water of the four 3-inch wells recently driven in the vicinity of the dug

wells, which now flows into one of the basins, contains an excessive quantity of iron in solution, which separates from the water after it is exposed to air. While the Newburyport water, as supplied to the city, contains at times a large quantity of iron, — probably sufficient to render it objectionable for some uses, — and the quantity of water obtainable from the proposed wells would be so small in proportion to the total quantity pumped that its effect on the general supply would be slight, the Board does not consider it advisable to draw this water directly into the distributing system, or to discharge it into one of the wells from which the regular supply is taken. If this water is allowed to flow into one of the basins near the pumping station, it will be available for use in a dry season or other emergency.

The plan in general, with the modifications suggested as to covering the reservoirs holding ground or filtered water, appears to the Board a practicable and appropriate one for increasing and improving the water supply of Newburyport.

North Adams (G. L. Rice, M.D.).

June 4, 1903.

To G. L. Rice, M.D., *North Adams, Mass.*

Dear Sir: — In response to your application for advice as to the quality of the water of a spring from which it is proposed to supply water for drinking purposes, the Board has caused the spring and its surroundings to be examined and a sample of the water to be analyzed.

The results of the analysis show that the water, while somewhat hard, is of suitable quality for drinking purposes at the present time. The watershed is free from buildings, and the only condition which appears to be likely to affect the quality of the water unfavorably is the use of the land about the spring for pasturage. By preventing the danger of the pollution of the source from this cause, the water of this spring may safely be used as a source of drinking-water supply.

Northfield (A. G. Moody).

Nov. 5, 1903.

To Mr. A. G. Moody, *East Northfield, Mass.*

Dear Sir: — In response to your request of October 21 for advice as to the quality of the water of certain test wells which you have caused to be driven in the level area bordering the Connecticut River north of Perchog Brook, with a view to obtaining a water supply for the village of East Northfield, the Board has caused the locality to be examined by one of its engineers, and samples of water from the test wells to be analyzed.

The results of the analyses show that the water of all three of the wells from which samples could be obtained contains an excessive quantity of iron, which would render it objectionable for many domestic uses, and the Board does not advise the use of water from these wells for domestic purposes.

It appears that you have also made tests in the neighborhood of the mouth of Louisiana Brook, with a view to obtaining a supply of water from the ground, but with unfavorable results. It is possible, in the opinion of the Board, that tests in the higher lands near Louisiana or Perchog Brook might give more favorable results than in the low lands bordering the river, and the Board would advise that, if further tests are to be made with a view to obtaining a water supply from the ground, they be made in the higher lands near these brooks.

Peabody.

Under the provisions of section 113 of chapter 75 of the Revised Laws, rules and regulations were made by the Board on Dec. 3, 1903, for preventing the pollution and securing the sanitary protection of the sources of water supply of the town of Peabody.

Dec. 3, 1903.

To the Peabody Water Board, Peabody, Mass.

Gentlemen: — The State Board of Health has adopted rules and regulations for the sanitary protection of the waters of the ponds and reservoir used as sources of water supply for the town of Peabody, in accordance with your request of November 5.

The Board finds that there is a large and increasing population near Brown's Pond and in the valley of its principal feeder, and, in its opinion, it will be difficult to adequately protect your water supply, and probably very soon impossible to do so, unless sewers shall be provided for removing the sewage from these thickly settled areas; and the Board would advise that you provide sewers as soon as practicable for the removal of sewage from the thickly settled portions of the water-shed of Brown's Pond.

Pittsfield.

Under the provisions of section 113 of chapter 75 of the Revised Laws, rules and regulations were made by the Board on Aug. 6, 1903, for preventing the pollution and securing the sanitary protection of the sources of water supply of the city of Pittsfield.

Plymouth (Plymouth Mills).

Aug. 6, 1903.

To Mr. William P. Stoddard, *Manager, the Plymouth Mills, Plymouth, Mass.*

Dear Sir: — In response to your application of June 23 for advice as to the quality of the water of a well near your machine shop on Billington Street, which you state is used as a source of drinking water by from 200 to 300 persons, the Board has caused the well and its surroundings to be examined and a sample of the water to be analyzed.

The results of the analysis show that the water is of good quality for drinking at the present time. While the well is located close to the build-

ings, it does not appear that sewage or other wastes from these buildings is discharged in such a way as to affect the quality of the well water, and there are no buildings on the slope of the hill above the well at the present time which might cause the pollution of the water.

In the opinion of the Board, this well is a safe source of drinking water under present conditions.

Reading.

April 2, 1903.

To the Water Commissioners of the Town of Reading.

Gentlemen: — The State Board of Health, in response to your request of Feb. 18, 1901, has made experiments at your pumping station in Reading during the past two years, to determine the feasibility of removing the excessive quantity of iron present in the water without increasing its hardness.

The objectionable character of the Reading water, as shown by numerous analyses covering a period of many years, is due to the presence, at practically all times, of an excessive quantity of iron and other mineral and organic matters. The quantity of iron present in the water varies greatly at different seasons of the year and even at different hours in a single day, and there is also a great difference in other chemical constituents of this water at different times.

The Reading water as drawn from the ground is not naturally a very soft water, but the hardness has decreased since the earlier years of its use; and the hardness in recent years has generally been less than 3 parts per 100,000 excepting in the winter and spring months, when it occasionally rises to 4 parts, and in two or three months has been slightly higher.

Thorough investigations made in previous years have failed to show any source in Reading or its immediate neighborhood from which a sufficient quantity of water of good quality can be obtained for the supply of the town, except at a considerably larger expense than would be required by this plan.

The present process of purification removes the excess of iron from the water, so that the water supplied to the town is now clear and colorless and free from taste or odor; but the hardness of the water is greatly increased by this process, and during the past two years has been about 9 parts per 100,000, or a little over three times as great as the hardness of the water when drawn from the ground, and is at times much greater, while the minimum hardness has rarely been less than 8 parts per 100,000. It has also been found that alum is frequently present in the filtered water.

The experiments and investigations of the Board have been directed to discovering a practical method by which the iron can be removed from the water without increasing its hardness, and without introducing lime or alum or other objectionable substance.

The results of the experiments show that, by bringing the water as drawn

from the ground into contact with metallic iron, the water will act upon the iron, taking up an additional quantity of this substance, which, together with the iron and organic matter originally present in the water, separates readily, and can be removed by filtration through sand at a fairly rapid rate.

By treating the water in the manner indicated, the excess of iron and organic matter is removed, and a clear, colorless and odorless water obtained, the hardness of which is little, if any, greater than that of the water as it is drawn from the ground. So far as known, this plan is, all things considered, the best practicable method of securing a satisfactory water supply for the town of Reading.

The works necessary for the purification of the quantity of water used by Reading by the plan found successful in these experiments could be installed at the present pumping station and filter-house without making very material changes or additions there. It would be necessary to provide a tank having a capacity of approximately 60,000 gallons, through which the water could flow slowly while being brought in contact with metallic iron. After the water had passed through this tank it would be necessary to filter it through a filter of fine, sharp sand, having a depth of at least 2 feet, and divided into two or more sections for convenience in cleaning.

The experiments indicate that the filters could be operated at a rate of 6,000,000 gallons per acre per day, and possibly at a rate as high as 10,000,000 gallons per acre per day. For the present consumption of water the area of filters required would probably be about 1,500 square feet; but, since the consumption of water is larger in summer, and it is desirable that the filter be operated during a part of the day only, it will be best to make the area larger, and an area of about 3,000 square feet should be provided in the beginning.

The present filters are not adapted for purifying the water by the process used in these experiments, but, since the area available in the filter-house is insufficient for the new filters, it will probably be best to allow the present filters to remain in place; and there will be a certain advantage in so doing, since the present filters could then be used nearly if not quite to the time when the new filters and works are available, and in this way the use of unfiltered water during the construction of new works can be avoided, excepting possibly for a very short period.

A storage tank for unfiltered water would be a desirable addition, as in the case of the present plant, and it is possible that the present storage tank could be utilized for this purpose.

It appears that, in connection with the present plant, there is an aerating basin having a capacity of about 21,000 gallons, which could probably be used in connection with the new system of purification, for the present at least, and thus avoid the necessity for constructing new tanks. To adapt these tanks for the purpose for which it is proposed to use them, it would

be necessary to introduce iron bars or plates in such numbers as to enable the water to take up a sufficient quantity of iron, and in such form that they could be readily removed from the tank for removing rust from the surfaces. The form of the plates or bars to be used will depend largely upon the cost of obtaining them, and any convenient form that is easily cleaned may be used.

The tanks should be so arranged that the water can flow through the series of compartments continuously, and provision should be made for cleaning the tanks and removing therefrom any sediment that may accumulate.

It will also be desirable to provide for aeration, but the present system of aeration can probably be superseded to advantage by the construction of an aerating tank above the present tanks, containing numerous small holes in its bottom, through which water can flow in fine streams, since experiment has shown that this form of aeration furnishes more satisfactory results.

In the maintenance of the works, besides removing sediment from the tanks, it would be necessary to occasionally scrape the sand filters to remove the iron and organic matter which would collect on their surfaces, and to replace the sand removed with clean sand from time to time. The labor involved in maintaining the works would probably be much less than in the maintenance of the present purification works.

If you decide to carry out the suggestions herein contained, the Board will advise you concerning the plans of the works, if you so request, and will give you such other assistance as it may in carrying out the work.

ROCKPORT.

JUNE 4, 1903.

To the Committee on Water Supply of the Town of Rockport, Messrs. CHARLES W. PARKER, FRANK O. LEWIS and CHARLES E. GREEN.

GENTLEMEN: — The State Board of Health received from you, on May 4, 1903, an application for advice as to the best method of improving the water supply of the town of Rockport, at the same time requesting the opinion of the Board upon the following questions: —

1. Would it improve the water to carry the intake farther up the pond, over a gravel and rocky bottom?

2. Would it improve the water to flush and give the entire system a thorough cleaning all at one time?

3. Is the glue factory within the water-shed of Cape Pond in its present location, and what ought to be done with it?

4. Would a mechanical filter render the water satisfactory to the town?

5. Is it necessary that something be done soon with the water in order for the town to retain its plant?

6. Can the committee cause to be removed the camp houses on the pond, and the people who cut ice made to clean up their premises?

You have also submitted a plan and the report of a test of a mechanical filter, which you have under consideration as a possible means of purifying the water.

The Board has caused the pond and its surroundings to be examined, in accordance with your request, and has considered the results of other examinations made by its engineers at previous times, and the results of analyses of numerous samples of the water, which show quite definitely its character, both before its use as a source of public water supply and in the years since that time.

The Board advised the authorities of Rockport, before the introduction of water, that Cape Pond would not be a desirable source of water supply unless the water should first be efficiently filtered, and called special attention to the necessity of preventing the pollution of the water of the pond by the glue factory on its water-shed before using the water as a source of public supply for the town.

The water of Cape Pond, as shown by the results of analyses covering a period of many years, has always been characterized by the presence of a large quantity of organic matter, largely in the form of microscopical organisms of kinds which impart to water a disagreeable taste and odor. These organisms are frequently present in very large numbers in the summer season, and the water at that season of the year is nearly always offensive to taste and smell.

It appears that, in addition to the offensive taste and odor of the water in the summer season, the water is rendered objectionable at times by the presence of a large amount of muddy sediment. It is possible that some relief from sediment in the water might be obtained by extending the suction main so as to take water over a clean bottom, as suggested in your application, provided the pipe should be made tight throughout its length. It is not likely, however, that water of noticeably better quality, excepting possibly in the matter of sediment, could be obtained by extending the suction main to the area of clean bottom which you have mentioned in your application.

In a pond of this depth there is often a material difference in the quality of the water at different depths, and there may be a stagnant layer of water in the bottom in the summer season which is very offensive. It is, therefore, desirable that a suitable intake be provided, whereby water can be drawn from Cape Pond at different depths; and it is advisable that this intake be located over a clean bottom, and that the danger of drawing mud into the pipes be prevented.

The glue factory in its present location is still within the water-shed of Cape Pond, and its wastes continue to pollute the pond. It is very important, in the opinion of the Board, that the further pollution of Cape Pond by sewage and wastes from the glue factory and from other buildings within its water-shed should be prevented as soon as possible; and this can be

done by enforcing the rules and regulations which have already been provided for the sanitary protection of the water of this pond. It is practicable to divert the glue factory wastes to some point outside of the water-shed, and this should be done without delay.

It is improbable, judging from the available experience in the filtration of waters containing great numbers of organisms, like that of Rockport, that a mechanical filter, such as that suggested by you, would remove the taste and odor from the water at the times when it is most objectionable; and if lime or alum, or both, should be used in this process, as has been suggested, the water would probably be rendered objectionable in other respects.

The danger of the pollution of the water of the pond from the camps and other buildings within its water-shed and from ice cutting and other causes can be prevented by enforcing the rules and regulations which have already been provided for the sanitary protection of the Rockport water supply.

In the opinion of the Board, the only practicable way of securing water of satisfactory quality from Cape Pond is to purify the water by filtration through sand. The results of recent experiments upon the purification of waters similar to that of Cape Pond have shown that such waters can be efficiently purified by filtration through sand; and the cost of the necessary works for purifying the Rockport water and rendering it satisfactory for domestic purposes at all times in that way would probably be considerably less than the cost of purifying the water, or securing a satisfactory supply by any other plan known to the Board.

The Board would, therefore, advise that you cause plans to be prepared for the filtration of this water, under the direction of an engineer of experience in matters relating to water supply, and an estimate to be prepared of the probable cost of the construction and maintenance of the necessary filters. The Board will advise you as to any plans which you may desire to present, and will assist you in making further investigations as to improving your water supply, if you so request.

RUSSELL.

MAY 7, 1903.

To Messrs. E. D. PARKS, J. G. BRENNAN and G. H. ALLEN, *Selectmen of the Town of Russell.*

GENTLEMEN: — The State Board of Health received from you, on April 27, an application for advice relative to taking the water of Black's Brook, about one-quarter of a mile above the point where it joins Bradley Brook, as a source of water supply for the town of Russell, and has caused the source to be examined by its engineer and a sample of its water to be analyzed.

The results of this and a previous examination show that the water is

soft, nearly colorless, and otherwise of good quality for the purposes of a public water supply; and, so far as can be judged from the information available to the Board, the flow of the stream is at all times sufficient to supply an ample quantity of water to the town.

The water-shed is a large one, containing several dwelling houses and farm buildings, most of which are located at a considerable distance from the stream or any of its tributaries. There is one house, however, located in the valley of one of the tributaries, from which polluting matters evidently find their way quite directly into the stream. If these buildings shall be removed and suitable precautions taken to prevent the pollution of the stream from any of the other buildings on the water-shed and from cultivated lands, the Board is of the opinion that this brook would be a suitable source of water supply for the town of Russell.

RUSSELL (WORONOCO PAPER COMPANY).

FEB. 5, 1903.

To Mr. JAMES F. BUSH, *Treasurer, Woronoco Paper Company, Fairfield, Mass.*

DEAR SIR: — In response to your communication relative to the danger of pollution of the brook from which your present water supply is drawn, the Board has caused the locality to be examined by its engineer, and has considered the conditions affecting the source.

The source is a mountain stream, designated on the State map as Potash Brook. It is exposed to very great danger of pollution at all times by the dwelling houses located in the valley of the brook, several of which are only a short distance above your dam. In one of these houses it appears that there are several cases of typhoid fever, and the conditions are such that there is great danger of the infection of the water of the stream from these cases.

In the opinion of the Board, the water of this source is unsafe for drinking at all times, and is especially dangerous at the present time, owing to the cases of typhoid fever above the reservoir.

The Westfield River is used as a source of supply at times, and this stream is also exposed to pollution from the villages and dwelling houses along the stream above Fairfield; and in this case, also, there is special danger in the use of this water at the present time, owing to the presence of many cases of typhoid fever in the villages farther up the stream.

Under the circumstances, the Board would advise that you direct all those to whom the water of either source is supplied not to use it for drinking or cooking unless it has been boiled. It would be better if water for drinking and cooking could be carried to the mill and village from some unpolluted spring.

The Board is informed that works are under construction for obtaining a supply from an unpolluted water-shed, and that these works will be pushed to completion as soon as the weather conditions will permit.

SALEM.

JAN. 7, 1904.

To the Board of Health of the City of Salem, Mr. R. L. NEWCOMB, *Clerk*.

GENTLEMEN: — The State Board of Health has caused an examination to be made of the Liberty Hill Spring, so called, in accordance with your request of Dec. 4, 1903, and has caused samples of the water to be analyzed chemically and bacterially.

The spring is located on the westerly side of Cold Spring Brook, north of Liberty Hill Avenue, a quarter of a mile from any apparent sources of pollution; but it appears to be possible for surface water flowing over the ground to find its way into the spring.

The results of an analysis of a sample of water show that the spring contains a somewhat larger quantity of organic matter and a larger number of bacteria than are found in good spring waters, which are probably due to polluting matters entering from the surface of the land adjacent.

The Board is of the opinion that, if the spring should be covered and protected from the entrance of pollution from the surface of the ground, the water would be safe for drinking while the other conditions in the neighborhood remain as at present.

SHARON.

MARCH 5, 1903.

To the Committee on Water Supply of the Town of Sharon, Dr. GEORGE W. FIELD, *Secretary*.

GENTLEMEN: — The State Board of Health received from you, on February 2, the following communication requesting advice relative to the water supply of the town of Sharon: —

The committee appointed by the voters of Sharon, Mass., to take the steps necessary to safeguard the water supply of the town, respectfully asks the advice of your Board upon the following points: —

1. Are any of the present buildings, barns, pig pens, cultivated land, etc., likely to become a menace to the purity of the water supply, *e.g.*: —

(*a*) The houses on Depot Street, near the railroad crossing.

(*b*) The railroad station.

(*c*) The town on the western slope, east of the railroad track.

(*d*) The Barbour house and barn.

(*e*) The Cynthia Bates house, etc.

(*f*) The Sharon Sanitarium; A. A. Carpenter's house, etc., and other possible sources of pollution in the course of the tributary brook.

(*g*) The territory about to be opened for development by J. A. Bowman and others.

(*h*) Street wash, from present or future streets and from the railroad station grounds.

(*k*) The farms and residences on Moose Hill.

2. Is the opening to settlement of the large tract along the proposed new road to Moose Hill likely to bring about conditions which might injure the quality of the water supply?

3. Where is the best location for additional wells or other means of additional supply?

4. Is it probable that the flow of the present wells can be increased by the storage of the waters of Beaver Hole Brook, by a dam at such a distance (feet) as to avoid all probability of injuring the quality of the water now furnished? In case it should store water as above, would the town incur liability of damage suits from owners of water privileges on the lower streams?

5. Is it advisable to take any special steps to maintain the purity of the waters of Beaver Hole Brook?

6. What lands, if any, should be taken for the purpose of ensuring a pure and adequate water supply?

7. In case any lands are taken, how should these be cared for?

In response to this application, the Board has caused the locality to be examined by its engineer and has considered the results of numerous analyses of samples of water from the well from which the water supply of Sharon is chiefly drawn covering a period of many years. These results show that the water is being polluted before entering the well, and that the pollution has increased since the first examinations were made, in 1887. In the earlier years the polluted water was very thoroughly purified before entering the well, and the purification of the water continues to be satisfactory, though there are indications of a slight deterioration in recent years. The water of the new wells is of about the same quality as that of the large well.

The information available to the Board indicates that the pollution by which the water of the wells is affected comes from the buildings in the neighborhood of the railroad and along the slope of the hill east of the wells. The buildings on the westerly side of the railroad, excepting the station and the first group of buildings nearest the wells, do not probably affect the quality of the water at the present time. The experience furnished by pumping water from the large well and from the new tubular wells indicates that very little water enters these wells from the region west or south of them, and that the water of these sources would not be materially affected if buildings should be constructed along the proposed new road to Moose Hill. A more thorough investigation by means of test wells would be necessary, however, to determine definitely that the waters of the present wells would not be unfavorably affected if the proposed plan of opening this land for buildings should be carried out.

The information available as to the quantity of water which the present wells are capable of yielding shows that the large well, the original source of supply, proved inadequate for the supply of the town in 1900, and water was drawn directly from Beaver Brook in that year. The new wells put in in 1901 are now used in connection with the large well, but the past two years have not been dry ones, and the yield of the new wells has not been tested. The available evidence shows, on the whole, that the quantity of water which they are capable of yielding, in addition to the supply obtain-

able from the large well, is small, and that all of the wells together are unlikely to furnish an adequate supply of water for the town in a dry season.

In the opinion of the Board, Beaver Brook is an unsafe source from which to take water directly for drinking or other domestic purposes, and it is unlikely that the yield of the present wells could be materially increased by the storage of the waters of Beaver Brook by a dam at a sufficient distance above the wells to avoid injuring the quality of their waters. It is probable that the supply from the region in which the present wells are located could be increased somewhat by putting in additional wells; but, owing to the nearness of this source to the village, the quality of the water would be likely to be similar to that of the present sources, and perhaps even more unfavorably affected by pollution if the proposed new road to Moose Hill should be opened for settlement.

The valley of Beaver Brook a mile or more above the present wells is uninhabited, excepting for a very few houses high up on the surrounding hills; and, judging from a superficial examination, contains considerable areas of porous soil, so that the conditions appear to be favorable to obtaining water of good quality freely from the ground by means of wells or other similar works. If tests of the ground in this region should show that a supply of good water could be obtained from the ground here at reasonable expense, this would probably be the best source from which to obtain a supplementary supply of water for Sharon, and it might be found to be for the best interests of the town to abandon the present wells and remove the pumping works to the new location.

If you decide to make further investigations relative to improving your water supply, the Board will, upon application, make the necessary analyses of samples of water, and when the results of further investigations are available, will give you further advice both as to the selection of a source and as to the means necessary to protect the purity of the water.

JUNE 4, 1903.

To the Water Supply Committee of the Town of Sharon, Dr. GEORGE W. FIELD, *Secretary*.

GENTLEMEN: — The State Board of Health received from you, on May 6, 1903, a communication requesting advice upon the following points: —

1. The advisability of resorting to deep bored wells, of at least 50 feet, and, in the opinion of C. A. Ray, a bored-well contractor, probably 150 to 250 feet deep.
(*a*) The proper location of such wells.
(*b*) The probable nature of the water supplied from such wells.
(*c*) What areas of land would you advise to be secured at the present time?
2. In case you recommend the utilization of the surface waters, what general plan do you advise?

It appears, from the information furnished the Board relative to the character of the material found in sinking the large well from which your

supply is now chiefly drawn, that this well was excavated to ledge on one side at least, and it also appears that the tubular wells which are used as auxiliary sources of supply encountered hardpan at no great depth beneath the surface. With these conditions it is likely that wells sunk to a greater depth in this locality would encounter ledge, and the experience with a great number of such wells in similar locations has shown that very little water can be obtained from them, the larger part of the water entering such wells probably coming from the soil above the rock. Water obtained in this way is not likely to be much different in quality from that of your present sources of supply, which, as you have already been informed in a previous communication, is being polluted before it enters your present wells.

Considering the circumstances, the Board does not deem it advisable for the town of Sharon to attempt to obtain an additional supply by sinking deep wells in the neighborhood of your present sources.

The conditions in the valley of Beaver Brook, a mile or more above your present wells, appear to be favorable for obtaining water of good quality freely from the ground by means of wells or other suitable works, as you have already been advised in a previous communication from this Board, and the indications are that water could be obtained freely from the ground in this region by means of wells of moderate depth. In this case also it is unlikely that there will be any advantage in the use of wells of the greater depths indicated in your application.

The Board is unable at present to give you any more definite advice than has already been given in its communication of March 5 last, and would again advise that you make tests in the valley of Beaver Brook above your present wells, to determine the practicability of obtaining an adequate supply of good water from the ground in this region. The Board would also advise that you secure the assistance in these investigations of an engineer of experience in matters relating to water supply. When you have made further tests the Board will, upon application, give you further advice in this matter.

SOUTHBRIDGE (AMERICAN OPTICAL COMPANY).

JUNE 4, 1903.

To the American Optical Company, Southbridge, Mass., Mr. C. M. WELLS, *Treasurer.*

GENTLEMEN: — The State Board of Health has considered your application for an examination of certain wells at your works in Southbridge, and advice as to the quality of the water, and has caused the wells and their surroundings to be examined and further samples of the water to be analyzed.

It appears that the supply for your upper group of buildings is at present drawn from two tubular wells, driven beneath one of the buildings to depths of 13 and 23 feet respectively, while the lower group of buildings, known

as the Lensdale works, is supplied from a tubular well 4 inches in diameter and 62 feet deep.

Analyses of samples of water recently collected from the upper wells show that the water of these wells has been highly polluted by sewage, though quite thoroughly purified in its passage through the ground before entering the wells. Comparing the recent analyses of the water of these wells with the analysis of a sample collected from the same wells on Aug. 20, 1900, it will be seen that there has been a very great deterioration in the quality of the water, which at the time of the earlier examination showed little or no evidence of sewage pollution.

Further analyses of the water from the well located in the factory at Lensdale, the use of which you were advised to discontinue in 1900, show that the quality of this water is worse than at that time.

The Board would advise that the further use of water from all of these wells for drinking purposes be prevented.

The results of an analysis of a sample of water from a spring on the opposite side of the river from your factory show no evidence of sewage pollution. The Board has already advised you that it is probable that water of good quality can be obtained from the ground on the opposite side of the river from the Lensdale works, if the water is collected at a sufficient distance from the river to avoid danger of drawing unpurified water from this source. A water of good quality can also be obtained from the public water supply of the town, though this water is often objectionable for drinking, on account of a high color or a disagreeable taste and odor. Objections from these causes can be removed by filtering the water through a sand filter, and an excellent supply of water for your works can be obtained in this way.

South Hadley.

Jan. 7, 1904.

To the School Committee of the Town of South Hadley, Mass., Mr. C. H. Davenport, *Chairman.*

Gentlemen: — In accordance with your application received Nov. 27, 1903, for advice as to the quality of the water used in the school building at South Hadley Centre, and your subsequent request for an examination of the water of a well at the school at South Hadley Plains, the Board has caused the wells to be examined and samples of their waters to be analyzed.

The results of the analyses show that the water entering each of the wells has been considerably polluted, and the number of bacteria present in the water of each was much higher when the examination was made than is found in good ground waters.

In the opinion of the Board, the water of both of these wells is unsafe for drinking, and the Board would advise that the further use of water from them be prevented.

Springfield.

Nov. 25, 1903.

To the Board of Health of the City of Springfield.

Gentlemen: — In response to your communications of October 28 and 30, requesting the Board to examine certain springs from which water is taken for drinking in the city of Springfield, the Board has caused the springs indicated by you to be examined and samples of their waters to be analyzed.

Four of these springs, known as the Pecousic, the Parkwood, the Indian and the Swan Pond springs, are situated in the public parks. Of these, the Parkwood is located not far from a sewer and at a lower level, and evidences of previous pollution are shown by the analysis, though at the time the sample was collected the water entering the spring did not contain an excessive quantity of organic matter. It would be advisable to discontinue the use of this spring. The water of the Pecousic Spring shows evidence of a high degree of pollution, and its further use should be prevented. The Indian and Swan Pond springs are located at a considerable distance from any apparent sources of pollution. The water of each spring shows evidence of contamination, and the number of bacteria present is higher than is found in good spring waters, and these springs cannot be regarded as safe sources of drinking water.

The Benton Park well, under the control of the park department, is highly polluted, as shown by analysis, and its further use should be prevented.

The water of Wesson's Spring shows evidence of much previous pollution, though at the time the sample of this water was collected for analysis the water entering the spring had been well purified in its passage through the ground. There are sources of pollution near the spring by which its quality may be at any time unfavorably affected, and it cannot be considered a safe source of drinking water supply.

The water of the Water's Spring, so called, near the corner of Hancock and Hickory streets, shows evidence of a high degree of pollution, and it has not been thoroughly purified by its passage through the ground before entering the spring. The further use of this spring should, in the opinion of the Board, be prevented.

Another spring located close to the Water's Spring is of even poorer quality, and must be considered unsafe for drinking.

The results of the examination of the water of a well used as a source of supply for the restaurant at the railroad station show that this water contains much organic matter, and, in the opinion of the Board, it is unsafe for drinking.

A spring located on the northerly side of the Boston & Albany Railroad near the Connecticut River is evidently very seriously polluted, and its use should be prevented.

The analysis of the water of the Collins' Farm Spring, so called, shows that some of the water entering this spring has been previously polluted, but at the time the sample was collected it had been well purified before entering the spring. The exact location of this spring, the water of which discharges through a small pipe, is apparently unknown; and while, so far as the analysis shows, the water is probably safe for drinking, the location of the spring should be ascertained, since there are possible sources of contamination at no very great distance from the present outlet pipe. In any case the water should be examined from time to time, in order that any deterioration may be detected, and the locality inspected to guard against local pollution.

The water of the Wilbraham Mountain Spring shows, upon analysis, very little change from previous examinations, and no change in the surroundings appears to have taken place which would affect the quality of the water. If local pollution of this source can be prevented, and sufficient care is exercised to prevent the pollution of the water in the process of collection and delivery to consumers, the use of this spring may be continued while the general conditions in its neighborhood remain as at present. The water should be analyzed, however, from time to time, in order that any deterioration that may occur may be detected.

The Iroquois and Massasoit springs are located in regions at present free from sources of sewage pollution. The chief danger to these sources is from pollution by visitors, especially in the case of the Massasoit Spring. The spring water should be collected and stored in covered basins or reservoirs, and possible danger of pollution prevented.

The water of the Hygeia Spring, so called, shows deterioration in some respects since previous examinations were made in 1901. The water entering this source has at some time been considerably polluted and subsequently well purified in its passage through the ground, and in its present condition is probably safe for drinking. The water is evidently very seriously polluted in the process of collecting and delivering it to consumers, and a method of collecting and delivering the water should be devised by which such pollution will be prevented.

The Board is informed that the further use of the Ingersoll Grove Spring, the apparent source of the recent typhoid fever epidemic, has been effectually prevented.

The Board would advise that all springs used by the public for drinking should be inspected from time to time, to guard against local pollution; and that all basins in which the spring water is collected be kept covered, and that the water be drawn through a suitable pipe, to guard against danger of contamination from those who take water from the spring.

Your attention is also called to the report of the results of examinations of many spring waters in the State presented in the annual report of this

Board for 1900. An examination of this report will show that spring waters are in many cases contaminated in the process of collection and delivery to consumers.

JAN. 7, 1904.

To the Special Commission on Water Supply of the City of Springfield, Mr. N. D. WINTER, *Chairman*.

GENTLEMEN: — Your communication, received Dec. 17, 1903, requesting information as to the highest rate at which it is practicable to filter surface waters for the removal of typhoid germs, has been considered by the State Board of Health.

The results of many experiments and of experience in the operation of sand filters show that rates of filtration as high as two and one-half million gallons per acre per day can be depended upon to remove the germs of typhoid fever. Beyond this limit the experience of the Board up to the present time indicates that safe results cannot be depended upon, though the limit varies somewhat with the quality of the water, and some good results have been obtained at rates greater than the rate stated above.

STERLING (STERLING INN).

JULY 2, 1903.

To Mr. JOHN H. COUGHLIN, *Manager, Sterling Inn, Sterling, Mass.*

DEAR SIR: — In response to your request of June 9 for an examination of the water of a well which you propose to use as a source of water supply for the Sterling Inn, the Board has caused the well and its surroundings to be examined and a sample of the water to be analyzed.

The results of the analysis show that, while the water is of good appearance, being clear, colorless and odorless, some of it has evidently been polluted by sewage and not thoroughly purified in its subsequent passage through the ground before entering the well. There are several sources of pollution in the neighborhood of the well, and, in the opinion of the Board, this well is not a safe source from which to take water for drinking or cooking.

STOUGHTON.

NOV. 5, 1903.

To Mr. GEORGE W. PRATT, *Chairman, Board of Selectmen and Board of Health, Stoughton, Mass.*

DEAR SIR: — The State Board of Health received from you, on Sept. 25, 1903, a communication requesting an examination of the public water supply of the town of Stoughton, and advice as to its quality and whether there is danger that it may injure the health of those who use it for drinking, and in response to this application has caused the sources of water supply of the town to be examined and samples of the water to be analyzed.

It appears from this examination that the sources now used by the town are the same as those which have been in use for several years. The prin-

cipal portion of the supply is drawn directly from Muddy Brook, which derives its flow from Muddy Pond, which in turn is supplied chiefly by the very large springs located within its water-shed. In addition to the water of the brook, a portion of the supply is derived from a well near the brook below Muddy Pond, and another, but apparently very small, portion from a filter to which the brook water is applied.

The quality of the water is affected by the organic matter in the pond and the swamp immediately about it, and also by the presence of microscopic organisms, and it is to these conditions that the taste and odor complained of in the water at times are doubtless due.

Organic matter of this kind, while making the water objectionable for domestic uses, is not known to be injurious to health; but a running stream in a region like this is not a safe source of water supply, on account of the danger of direct pollution of the stream or its tributaries from buildings located on the water-shed or by persons resorting to the neighborhood, because polluting matters deposited upon the water-shed in the immediate neighborhood of the stream or its tributaries would be likely to be carried quickly to the consumers of the water.

The original plan of supplying water to the town provided for taking the water from a well near the brook; but the works, after construction, were found wholly inadequate to supply sufficient water without drawing water directly from the brook, and since that time plans for securing an adequate supply of ground water from the water-shed of Muddy Brook have been considered several times by the Board in response to applications from the authorities of the town.

The most recent of these applications was received from the Stoughton water commissioners in 1899, and the reply of the Board to this application, dated Oct. 6, 1899, was in part as follows: —

The Board has caused your present works and the region about Muddy Pond to be examined by its engineer, and samples of water collected by you at various points from the brook flowing from Muddy Pond to be analyzed, and has carefully considered the plan submitted and the results of previous investigations with reference to the water supply of Stoughton.

The water supplied to the town from your present works is at times highly colored, and contains a large quantity of organic matter taken up from the swamp about Muddy Pond. The water-shed of Muddy Pond is situated quite near the town, and, while it contains only a small population, and the pond and brook below it are but little exposed at the present time to danger of pollution by sewage, the use of a running stream in such territory as a source of public water supply should, in the opinion of the Board, be avoided. . . .

The examinations which have been made under the direction of the Board during the present year tend to confirm the conclusions based on the result of examinations made in previous years, — that a supply of ground water of excellent quality, sufficient for the needs of the town of Stoughton for the present and probably for a long time in the future, can be obtained by constructing suitable

works for collecting the ground water which now finds its way into Muddy Pond and the brook below it above your present collecting well; and, in the opinion of the Board, it is very desirable that works be built with as little delay as possible, to secure a supply of water for the town from this source.

It is important, before making any changes in your present works, to make further investigations and to prepare definite plans for collecting all of the spring water which can be made available; and when such investigations as may be necessary have been made and definite plans for the proposed works have been prepared, the Board will advise you concerning them, if you so request.

The Board would advise the town to proceed immediately with investigations and plans for securing a supply of ground water, as advised in the reply of the Board quoted above. The Board would also advise the town to cause rules and regulations for the sanitary protection of the water supply, as provided in chapter 75 of the Revised Laws, to be made and put in force without delay, in order to secure such protection of the health of the inhabitants of the town as is practicable in this way.

Uxbridge.

JAN. 7, 1904.

To the Board of Water Commissioners of the Town of Uxbridge.

GENTLEMEN: — In accordance with your request of Dec. 8, 1903, for advice as to the quality of the water of a well in Capron's mill yard, which you propose to use temporarily as a source of water supply, the Board has caused a further examination to be made of the well and its surroundings and additional samples of the water to be analyzed.

This source has already been examined on several previous occasions by this Board at your request, with a view to its use as a temporary source of water supply, and in 1896, after a careful examination of this source, the Board advised you as follows: —

Under the most favorable conditions, when little or no water has been drawn from the well for a long time, the quality of the water is not objectionable for the purposes of a public water supply.

All the analyses show that the water had previously been polluted and subsequently purified in a large degree in its passage through the ground to the well, but some of the analyses show the presence of a very large amount of free ammonia in the water, indicating that at such times the water entering the well is not thoroughly purified.

There is reason to expect, therefore, that, if water is pumped from this source in such quantity as would probably be necessary for the supply of the town, imperfectly purified water from the sewage-polluted sources in the vicinity may enter the well, and under the circumstances the Board does not consider this well a safe source of domestic water supply.

The analyses made since 1896 show the presence of a much larger quantity of free ammonia than had been found up to that time, and the quantity of chlorine found to be present in the two samples analyzed recently was

nearly three times as great as the quantity present in any sample examined previous to 1896, — showing that the water is of poorer quality than at the time the advice quoted was given.

The Board considers this well an unsafe source of drinking water supply, and advises you not to introduce this water into the water supply system of the town. In the opinion of the Board, the neglect of the town to provide an adequate supply of pure water for drinking and other domestic purposes is a serious menace to the health of the people.

Waltham.

Nov. 5, 1903.

To the Board of Health of the City of Waltham, Mr. A. Lincoln Moody, *Agent.*

Gentlemen: — The State Board of Health received from you on Oct. 5, 1903, a communication requesting an examination of the water of the Constitution Spring, so called, in Waltham, and advice as to its quality, and in response to this request has caused the spring and its surroundings to be examined and samples of the water to be analyzed.

The results of the analyses show that the water as drawn from the ground has been slightly affected by pollution at some point, though the polluting matters have been well purified before reaching the spring. The pollution of the ground water may be caused by the farm buildings about 800 feet from the spring, though the quality of the water may also be affected somewhat by the use of fertilizers on lands above the spring. While the spring is in use as a source of drinking-water supply, care must be taken to prevent the deposit of polluting matters upon lands in the neighborhood of the spring, and to prevent foul drainage from the farm buildings from flowing over the ground to the neighborhood of the spring. The examinations made by the Board indicate that the water of this spring in its present state is safe for drinking, but it is desirable, on account of the situation of this spring, that analyses of the water be made from time to time, in order that any deterioration in its quality may be detected.

An analysis of a sample of water from a carboy in the factory of the American Waltham Watch Company, containing water said to be supplied from this spring, was found to contain a very large number of bacteria, which may have been due to lack of care in the cleaning and filling of the carboy, or to the lack of care in preserving the purity of the water by those handling the carboy in the factory.

While the water as it comes from the spring is of good quality for drinking, it may be rendered unsafe for drinking by lack of care in handling and distributing the water; and it is of the greatest importance that the water should be delivered in clean vessels, and kept from danger of pollution from the time it leaves the spring until it is used.

WAYLAND.

APRIL 27, 1903.

To Messrs. WALTER B. HENDERSON, CHESTER B. WILLIAMS and JOHN CONNELLY,
Special Committee of the Town of Wayland.

GENTLEMEN:—The State Board of Health received from you, on March 31, an application requesting the advice of the Board as to the improvement of the water supply of Wayland, in which you state that the town is planning to expend $2,000 in cleaning the present reservoir and removing mud from the bottom, and that you are considering the question of extending the present system to supply the centre of the town; and in response to your application the Board has caused the reservoir and its surroundings to be examined by its engineer, and has considered the results of numerous analyses of the water of this source made recently and in past years.

It appears, from the information available to the Board, that water can be drawn at present either directly from the reservoir or from a filter-gallery extending along the shore of the reservoir for a distance of about 400 feet, with two branches extending beneath the bottom of the reservoir.

The results of analyses show that the water of the reservoir is generally highly colored and contains frequently an excessive quantity of organic matter, and that it is often objectionable for drinking and other domestic purposes on account of a disagreeable taste and odor. The objectionable quality of the water of the reservoir is evidently due principally to the character of the reservoir, which is very shallow, and contains much organic matter in its bottom.

The water of the filter-gallery contains less organic matter than water taken directly from the reservoir, but this water, which is derived largely from the pond by filtration through the ground, is generally affected by an excessive quantity of iron, due to the imperfect filtration of the water, and by a disagreeable taste and odor which render it objectionable for domestic purposes.

The water of the filter-gallery cannot probably be improved by any changes that it is practicable to make either in the reservoir or in the gallery itself. The waters of other filter-galleries in the State which have been constructed, like this one, beneath, or in very close proximity to, the shores of a pond, stream or reservoir, have in all cases been found to be objectionable on account of the presence of an excessive quantity of iron, as in this case; and the only means of improving the water of the filter-gallery, if it is to be continued in use, will be to filter it through sand in such a way as to remove the excessive quantity of iron.

The water of the reservoir can doubtless be considerably improved by a thorough cleaning of the bottom, and the removal of all mud, stumps and other organic matter from the area covered by water, and by the drainage of swamps on the water-shed; but the cost of removing a sufficient portion

of the organic matter in this reservoir to have a noticeable effect in improving the quality of the water would doubtless be very much greater, judging from the information available to the Board, than the sum mentioned in your application.

It will be impossible to clean the reservoir without drawing out the water, and the flow of the brook above the reservoir would not be sufficient during the summer season to supply the village while the improvement was being made, so that a temporary supply from some other source would be necessary.

The Board has also considered the suggestion of extending the works so as to supply the central village of Wayland. It appears, from such information as is available to the Board as to the capacity of your storage reservoir, the size of its water-shed and the quantity drawn from the source at present, that the capacity of this source in a very dry season is but little, if any, in excess of the quantity now being used by the village of Cochituate alone; and if the supply should be extended to the central village of Wayland, it is likely that an additional quantity of water would soon be required from some other source to meet the requirements of the town in a dry season, especially since a considerable quantity of water is liable to be used from your present source for running the pumps to increase the pressure needed for fire purposes.

Considering the probability that the present source would soon prove insufficient for the supply of Wayland, should the extension now proposed be made, and considering that, even if the reservoir should be thoroughly cleaned and the swamps on its water-shed drained, the quality of the water of this source would still be likely to be objectionable, the Board would advise that you make investigations of the feasibility and probable cost of obtaining a supply of ground water from some source in the neighborhood of the village. A good ground-water supply would be far more satisfactory for all domestic purposes than the water of your present source, even after all the improvement practicable had been made therein, on account of the freedom of ground water at all times from color, taste and odor, and its lower temperature in the summer season.

The Board would advise that, in making further investigations, you secure the assistance of an engineer of experience in matters relating to water supplies; and when you have made further investigations the Board will, if you so request, give you further advice in this matter.

Wellesley (Wellesley College).

Nov. 5, 1903.

To the Trustees of Wellesley College, Wellesley, Mass.

Gentlemen: — In response to an application for an examination of the water of a driven well located on the grounds of the college near a new power plant, and advice as to its quality for drinking purposes, the Board

has caused the well and its surroundings to be examined and samples of its water to be analyzed.

The results of the analyses show that the water at the time these samples were collected was of good quality for drinking. It appears, however, that sewage is deposited upon the ground at several places, from which ground water apparently drains toward the well, and at no great distance from it.

Under the circumstances, the Board would advise that, before using water from this source for drinking or other domestic purposes, a test be made by pumping from the well for a period of two weeks or more, and at a rate as great or greater than that at which water would be drawn if the well should be used as a source of supply. If, upon such a test, the water remains satisfactory, it is probable that this source could be used with safety, though its quality should be tested from time to time.

If you decide to make a pumping test, as suggested, samples of the water should be collected for analysis from time to time during the test; and if you decide to make this test the Board will, if you so request, make the necessary analyses of the water and give you further advice as to its quality.

The Board is informed that a sewer from the new dormitory will, when constructed, pass within about 100 feet of this well. If the well is to be used as a source of drinking-water supply, the sewer should be located at a greater distance from the well, if practicable; and if the sewer is to be built anywhere in the neighborhood of the well, it should be very carefully built of iron pipe laid with lead joints like a water pipe, and tested before using, to see that the joints are tight.

Westford (Caleb L. Smith).

Aug. 6, 1903.

To Mr. Caleb L. Smith, *455 Middlesex Street, Lowell, Mass.*

Dear Sir: — In response to your request of July 6, for advice as to the quality of the water of a spring located in Westford and used as a source of drinking-water supply, the Board has caused the spring and its surroundings to be examined and a sample of the water to be analyzed.

The results of the analysis show that the water at the present time is of excellent quality for drinking.

An examination of the surroundings of the spring shows that it is located in a tract of woodland, and, with the exception of an abandoned camp not far from the spring, there are no buildings in its neighborhood.

In the opinion of the Board, the spring is at the present time an excellent source of drinking-water supply.

Westwood.

June 4, 1903.

To the School Committee of the Town of Westwood.

Gentlemen: — In response to your request of April 15, for advice as to the quality of the water of the well in the yard of the Colburn School in

Westwood, the Board has caused the well and its surroundings to be examined and samples of the water to be analyzed.

The results of the analyses show that the water at the time that these examinations were made, on April 21 and May 6 respectively, was clear, colorless and odorless, and was not affected by sewage pollution.

There do not appear to be any sources of sewage pollution in the immediate neighborhood of the well, but the platform over the top is loose, and water falling upon this platform or immediately about the well runs freely back into it, — a possible source of contamination, which should be prevented. If the stone work about the well should be made tight for a distance of 5 feet from the top, and the well covered with a tight cover, polluting matters might be kept from entering, and the water of this well would be safe for drinking.

In case the water should have an objectionable taste and odor after the improvements suggested have been made, the Board will, upon notice from you, immediately make an examination to ascertain the cause of the objectionable condition of the water.

Weymouth.

Under the provisions of section 113 of chapter 75 of the Revised Laws, rules and regulations were made by the Board on Sept. 3, 1903, for preventing the pollution and securing the sanitary protection of the waters of Weymouth Great Pond and its tributaries, used by the town of Weymouth as a source of water supply.

Wilbraham (L. E. Taft).

June 4, 1903.

To Mr. L. E. Taft, *Wilbraham, Mass.*

Dear Sir: — In response to your request of May 13, for a further examination of the water of the Wilbraham Mountain Spring, so called, in Wilbraham, and advice as to the quality of its water, the Board has caused the spring and its surroundings to be examined and a sample of the water to be analyzed.

The results of the recent analysis show, on the whole, a slight improvement in the quality of the water since the previous examination was made by the Board. It appears that the cistern in which the spring water is collected, the pipe line from the spring to the receiving basin, and the receiving basin, have recently been reconstructed, so as to prevent the entrance of surface water, and that provision has also been made for filling the receptacles in which this water is sold directly from the pipe, so that danger of contaminating the water in this process is avoided.

In the opinion of the Board, the water of this spring, under the conditions which now exist, is safe for drinking.

WILLIAMSBURG.

APRIL 2, 1903.

To Messrs. H. C. SMITH, *Chairman of Selectmen*, and A. G. CONE, *Secretary of Water Committee, Williamsburg, Mass.*

GENTLEMEN: — The State Board of Health received from you, on March 5, a communication requesting the advice of the Board as to the propriety of taking water for domestic and other purposes in the town of Williamsburg from Unquomonk and Meekins brooks; and subsequently plans were received from your engineer, Mr. E. E. Davis of Northampton, showing the proposed works for taking a supply of water from Unquomonk Brook. The plans provide for two reservoirs on this brook, the upper one designed to store 5,000,000 gallons and the lower one 500,000 gallons. From the latter a pipe line will convey the water to the villages of Williamsburg and Haydenville by gravity.

In response to this application the Board has caused the sources to be examined by its engineer and samples of their waters to be analyzed. So far as can be judged from the information available to the Board, it is probable that the water of Unquomonk Brook will be of somewhat better quality than that of Meekins Brook; and the water-shed of Unquomonk Brook has the further advantage that it contains a smaller number of dwelling houses, and there will be less difficulty in preventing danger of pollution of the water from such places.

Unquomonk Brook above the lower reservoir has a water-shed of a little less than one square mile, and no observations upon the flow of the stream in dry weather are available which would serve to indicate the probable quantity of water which this source will yield in a very dry season. The Board is informed that the flow is well maintained in dry weather, and, with the aid of the reservoirs provided for in the plans, it seems likely that this source will furnish a sufficient quantity of water for all the requirements of Williamsburg, unless there is a material increase in the population of the town, or unless a large part of the water is wasted.

The water-shed of Meekins Brook is somewhat larger than that of Unquomonk Brook, and it is probable that, by the construction of storage reservoirs, a much larger supply could be obtained from this source than from Unquomonk Brook, but the quality of the water would probably be somewhat less satisfactory.

Considering the circumstances, the Board is of the opinion that Unquomonk Brook is an appropriate source of water supply for Williamsburg, and, if the reservoirs and pipe lines indicated on the plan are built in a thorough and substantial manner, this source is likely to furnish an adequate supply of good water for the town until its requirements increase considerably over what they are at present. If, in the future, on account of an increase in the population of the town or loss of water by leakage or waste,

an additional supply becomes necessary, a supplementary supply can then be taken from Meekins Brook. It may also be possible, judging from the State map, to supplement the yield of Unquomonk Brook by diverting into it the water of some other stream in its neighborhood by gravity.

JUNE 4, 1903.

To Messrs. HENRY C. SMITH, JOHN W. HILL and ALBERT S. HILL, *Board of Water Commissioners for the Town of Williamsburg.*

GENTLEMEN: — The State Board of Health received from you, on May 15, an application requesting the advice and approval of this Board of the taking of water by the town of Williamsburg for domestic and other purposes from Unquomonk Brook, under the provisions of chapter 349 of the Acts of the year 1901 and of chapters 182 of the Acts of the year 1902 and 139 of the year 1903, and in response to this application has caused the proposed source of supply to be examined by its engineer and samples of its waters to be analyzed.

The results of analyses of the water of Unquomonk Brook show that it is soft and practically free from color, taste and odor, and otherwise of excellent quality for the purposes of a public water supply. The watershed contains only two dwelling houses, both of which are located at a considerable distance from any of the streams, so that it will be practicable for you to prevent the pollution of the water of the brook by sewage from these houses without serious difficulty.

The plans presented by your engineer, Mr. E. E. Davis of Northampton, provide for an intake reservoir upon this brook at a point where the watershed of the stream is somewhat less than one square mile, with a storage reservoir located farther up stream, in which it is proposed to store about 5,000,000 gallons of water. If the dams creating these reservoirs shall be constructed in a thorough and substantial manner, so as to prevent serious loss of water by leakage, and if reasonable care is taken to prevent excessive use or waste of water in the town, Unquomonk Brook is capable of furnishing an adequate supply of water for the present requirements of Williamsburg, and it appears to be practicable to increase the supply from other sources in the neighborhood with no great difficulty, if found necessary in the future.

The Board hereby approves the use of Unquomonk Brook according to the proposed plan as a source of water supply for domestic purposes for the town of Williamsburg. The Board would advise that the reservoirs to be constructed on Unquomonk Brook, as indicated upon your plans, be prepared for the storage of water by the removal of all the peaty soil and organic matter now covering the surface of the ground at the location of these reservoirs.

WILLIAMSTOWN.

OCT. 1, 1903.

To the Williamstown Water Company, Williamstown, Mass., Mr. C. G. SANFORD, *Superintendent.*

GENTLEMEN: — In response to your request for an examination of the water supply of Williamstown, and advice as to the cause of an odor in the water of Sherman Spring during the past summer and as to the best method of preventing trouble from this cause, the Board has caused the source of supply and its surroundings to be examined and samples of the water to be analyzed.

The results of the examination show that the reservoir in which the water of Sherman Spring is collected contains a large growth of organic matter, both of larger organisms clinging to the sides and bottom of the reservoir and probably also of microscopical organisms in the water itself; and it is probable that the disagreeable taste and odor complained of by those to whom this water is supplied are caused by the presence of this organic matter.

Experience has shown that where a ground water, such as that of Sherman Spring, is stored in an open reservoir, as in this case, organisms grow in abundance, and impart a disagreeable taste or odor to the water.

The only practicable method now known to the Board for preventing the deterioration of ground waters is to keep them from exposure to light from the time they leave the ground until they are delivered to consumers; and there is no doubt that by covering the reservoir in which the water of Sherman Spring is stored the growth of organisms in the water will be prevented, and the objectionable taste and odor avoided.

It appears that the Paul Brook reservoir, located alongside the Sherman Spring reservoir, is connected with the latter source, and that the water of Paul Brook reservoir is also affected by a taste and odor. It is possible that the water of Paul Brook reservoir is unfavorably affected by the introduction of water from the Sherman Spring reservoir, and that if these reservoirs should be wholly separated the water of Paul Brook reservoir would not become seriously objectionable in the summer season.

The Board would advise that you provide a covered reservoir for the storage of the water of Sherman Spring, so that it can be delivered to consumers without exposure to light, and that the water be kept separate from the water of the Paul Brook reservoir. If the water of the latter reservoir should still be affected by the presence of organic growths and a disagreeable taste and odor, this reservoir should also be covered so as to exclude light. If it is not practicable to cover the whole of the reservoir at a reasonable expense, a portion might be separated from the remainder and kept covered, and the open reservoir used only in cases of emergency.

The Board would again call attention to the fact that the quantity of water which all of your sources together are capable of yielding is inadequate for the supply of the town in a dry season, and would urge that an adequate additional water supply be provided without delay.

WOBURN.

DEC. 24, 1903.

To Mr. ELWYN G. PRESTON, *Commissioner of Water and Water Supply of the City of Woburn.*

DEAR SIR: — In response to your request of October 10, for an examination of the water supplied to the city of Woburn to determine whether or not it has recently deteriorated in quality, the Board has caused the source of supply to be examined by its engineer, and has considered the results of numerous analyses of the water of the filter-gallery made in the last fourteen years.

The evidence furnished by a comparison of the analyses of the waters of Horn Pond and of the filter-gallery and by an examination of the locality shows that the water which enters the filter-gallery is derived very largely from Horn Pond by filtration through the ground.

The results of the analyses of the water of the filter-gallery made in past years show that nitrification in this water has decreased since 1891, and that the purification of the water passing through the ground from Horn Pond is becoming less thorough, as shown by the gradual and steady increase in the quantity of free ammonia present in this water since 1891. There has also been an increase in the quantity of iron present in the water, which has become much more marked in the last three years; but the quantity present has not yet become great enough to affect noticeably the quality of the water for drinking or other domestic purposes. The changes which have taken place in the quality of the water since 1891 are coincident with a gradual increase in the consumption of water from the filter-gallery since that year.

The only remedy for this deterioration which the Board can suggest, with its present information, is to diminish the draft on the filter-gallery so that it shall not exceed the quantity which was being drawn from the gallery before the change in the quality of the water began.

In order to diminish the draft on the filter-gallery, it will be necessary to secure an additional supply from some other source. While the present filter-gallery has hitherto furnished an adequate supply of water for all the requirements of Woburn, there are indications, furnished by the experience of the last few years, that the quantity of water now used is in excess of the capacity of the source in a dry season, and, in the opinion of the Board, it is very important for the city to make plans for securing an additional supply of water.

Considering these circumstances, the Board would advise that you cause investigations to be made of all available sources from which it is likely that an adequate additional water supply may be secured, and that in making these investigations you secure the assistance of an engineer of experience in matters relating to water supply.

It is possible that an adequate additional supply can be obtained by the construction of another filter-gallery, or by means of wells at some place near Horn Pond at a sufficient distance from the present filter-gallery to be beyond the territory which now furnishes ground water to that source; and it is possible that there may be other sources from which an adequate additional supply of water can be obtained. A supply of water can be obtained from the metropolitan water district, and this may be the most economical plan of securing a water supply for the future.

If you decide to make investigations for an additional water supply, the Board will give you such assistance as it can by making the necessary analyses of water, and will give you further advice in this matter when the results of further investigations are available.

An examination as to the cause of a complaint recently made as to a taste and odor in the water shows that it is without doubt due to the presence of microscopical organisms which appear in the open reservoir used in connection with your present works. Trouble from this cause can be obviated by covering the reservoir so as to prevent the exposure of the water to light, as the Board has already advised at a previous time.

It appears that lead pipes or iron pipes lined with lead are now used as service pipes in the delivery of water to consumers in Woburn, and the Board has caused analyses to be made of several samples of water collected from several houses supplied through such service pipes. The results of these analyses show that a sufficient quantity of lead may be taken up by the water in passing through lead or lead-lined pipes to cause injury to the health of those who use the water for drinking.

Changes in the character of the water are liable to cause it to take up greater quantities of lead, and the Board would advise that in future you avoid the use of lead or lead-lined pipes for service pipes. Pipes of tin or of iron lined with tin or with cement will not injure the quality of the water supplied through them.

Wrentham.

July 2, 1903.

To Mr. Charles W. Pond, *Chairman, Board of Selectmen, Wrentham, Mass.*

Dear Sir: — In response to your request of June 6, for an examination of the Indian Red Spring, so called, used as a source of water supply for a hotel near Lake Pearl in Wrentham, and advice as to its quality, the Board has caused the spring and its surroundings to be examined and a sample of the water to be analyzed.

The results of the analysis show that the water at the present time is of good quality for drinking, and it does not appear that its quality is being affected by the sewage of the hotel, which is discharged into a cesspool some 400 feet from the spring.

If care is taken to prevent the deposit of polluting matters immediately about the spring, the Board is of the opinion that this water may safely be used for drinking.

Ice Supplies.

The following is the substance of the action of the Board during 1903 in reply to applications for advice relative to sources of ice supply: —

Cohasset.

Aug. 6, 1903.

To Mr. Harvey H. Pratt, *30 Court Street, Boston, Mass.*

Dear Sir: — In response to your communication of June 5, calling the attention of this Board to the condition of the ice taken from a meadow or pond adjacent to the New York, New Haven & Hartford Railroad near the King Street station in Cohasset, which is sold in Hull and its vicinity, the Board has caused the pond and its surroundings to be examined and several samples of the ice to be analyzed.

The small and shallow pond from which the ice was harvested contains much organic matter in its bottom, and there is evidence that the source was exposed to pollution by sewage during last winter from camps near its shore. The results of the analyses and examinations of the ice show that it contains much foreign matter, evidently taken up by the ice from the bottom or sides of the pond.

The source is an objectionable one, and, in the opinion of the Board, the ice harvested from this source cannot safely be used where it would come in contact with food or drinking water.

Nov. 10, 1903.

To Mr. Harvey H. Pratt, *Counsel for Petitioners relative to an Ice Supply in Cohasset and Hull.*

Dear Sir: — The State Board of Health received from you, on August 18, the following petition: —

To the Honorable the Board of Health of the State of Massachusetts: —

Respectfully represent your complainants, consumers of ice, cut from a certain meadow or pond, lying in and within the limits of the town of Cohasset, on the westerly side of the tracks of the New York, New Haven and Hartford Railway Company, near the power plant, so called, of the Cohasset Electric Light and Power Company, —

That the ice cut from said meadow or pond is sold and held for sale, and is impure and injurious to the public health.

That your complainants are informed and believe that said ice is sold and held for sale by Smith and Hatchard of Hull, in the County of Plymouth, of said Commonwealth.

Wherefore they pray that notice may issue to said Smith and Hatchard, and any other person, individuals or corporations interested in the sale or holding for sale of said ice, and that your Honorable Board will make such order relative to the sale thereof as in its judgment the public health requires.

In response to this petition, the State Board of Health, acting under the provisions of chapter 75 of the Revised Laws, gave a hearing at its office on Thursday, Oct. 1, 1903. The Board has also caused an examination of the ice pond in question to be made and several samples of the ice harvested from this pond in the winter of 1902–03 to be analyzed, the results of these analyses showing the presence of much foreign matter in the ice.

The ice pond in question is located on the south-westerly side of the New York, New Haven & Hartford Railroad, about a quarter of a mile east of the King Street station. The pond has been formed artificially by the flooding of a swampy area by means of a low dam, and the bottom, at the time the source was examined recently, contained a large number of stumps and a large growth of grass. Under these conditions, when the water freezes, grass and other organic matters are liable to be included in the ice, as appears to have been the case last year.

In the opinion of the Board, the only way in which ice of good quality may be obtained from this source is by cleaning the bottom of the pond in that portion of the area from which ice is harvested, by the removal of the stumps and vegetable matter and by taking ice only from the portions of the pond having a bottom prepared in this way; and by removing from the ice, after cutting, the first inch that formed and all snow ice or ice formed by flooding, and excluding all ice that contains particles of foreign matter. It appears that the recognized dangerous sources of pollution of this pond have been removed; and the conclusion of the Board is that, if the bottom of the pond shall be cleaned and the pollution of the water in future prevented, ice harvested from this pond in the manner herein suggested may be used for domestic purposes.

FALL RIVER.

MARCH 5, 1903.

To Messrs. BAKER & THURSTON, *Attorneys* for Mr. FRED M. SHAW, *Fall River, Mass.*

GENTLEMEN: — The State Board of Health has considered your request for an examination of a pond on Steep Brook in Fall River, used as a source of ice supply, and the ice cut therefrom during the present winter, and has caused the pond and its surroundings to be examined by one of its engineers and samples of the water and ice to be analyzed.

An examination of the water-shed of the pond shows that it contains a considerable number of dwelling houses, including a contagious-disease hospital, and sewage from some of the buildings may at times find its way into the brook; but it is understood that the hospital was not occupied previous to the time this ice was harvested, and there was no evidence at

the time the examination was made that the brook was being polluted from any of the other sources examined.

The analysis of a sample of ice from the ice house near the pond showed that the ice was of good quality, and the Board does not consider that this ice is unsafe for domestic use.

Gloucester.

May 7, 1903.

To the Board of Health of the City of Gloucester, Mr. James R. Jeffery, *Clerk*.

Gentlemen: — The State Board of Health received from you, on Feb. 6, 1903, a communication requesting its opinion as to the quality, for domestic use, of the ice cut from Lily Pond near Day Avenue in the portion of Gloucester known as Lanesville; and in response to this request the Board has caused the source indicated to be examined and samples of the water and ice to be analyzed.

At the time this examination was made there were certain sources of pollution on the water-shed of the pond, the chief of which were some manure piles on the side of the pond opposite the ice house, but the Board is informed that these were placed there after the ice was harvested.

A sample of the water, collected from the pond in the latter part of February, was found to contain much organic matter. Three samples of the ice have been analyzed chemically and bacterially, the results showing the presence of a larger quantity of organic matter and bacteria than is found in ice formed under favorable conditions.

The ice stored in the ice house apparently contained considerable foreign matter, and, considering all the circumstances, the Board does not consider this ice suitable for use for domestic purposes where it would come in contact with food or drinking water.

Dec. 3, 1903.

To the Board of Health of the City of Gloucester, Mr. James R. Jeffery, *Clerk*.

Gentlemen: — The State Board of Health received from you, on November 13, a communication requesting an examination of Webster's Pond in Gloucester and of the ice cut therefrom, and advice as to the use of this pond as a source of ice supply; and in response to this application has caused the pond and its surroundings to be examined and samples of the water and of the ice harvested from the pond last year to be analyzed.

The results of the examination of the surroundings of the pond show that there is a large number of dwelling houses and other buildings within its water-shed near its westerly shore, and there is evidence that much refuse and drainage find their way into the pond in this region, and a chemical analysis shows that the water of the pond is being polluted at the present time.

The ice found in the ice houses near the pond was very variable in quality, some of it being quite clear, while other portions contained much foreign matter. A sample of the ice was found, upon analysis, to contain

a considerable quantity of organic matter and a very much larger number of bacteria than is found in good ice.

It is possible that ice may be obtained from the deeper portions of this pond, which may be safely used for domestic purposes by removing from the ice the first inch that formed upon the pond and all snow ice or other ice formed by rain or flooding above this first inch, and retaining only the clear ice beneath the first inch which formed upon the pond. It is very important that ice be harvested only from the deeper portions of the pond, where there are two feet or more of water between the ice and the bottom of the pond, and that no ice containing weeds or foreign substances be used. If these conditions are carefully observed, it is likely that ice which may be safely used for domestic purposes can be obtained from this source. Polluting matters should, however, be kept out of the pond.

Huntington.

April 2, 1903.

To the Board of Selectmen of the Town of Huntington, Mr. L. F. Hardy, *Chairman.*

Gentlemen: — The State Board of Health received from you, on March 5, a communication requesting the advice of the Board as to the quality for domestic purposes of ice taken from a mill pond on the east branch of the Westfield River in Huntington, a little less than a half a mile above the point where the east branch joins the west branch of the Westfield River; and in response to this application the Board has caused the locality to be examined by one of its engineers and has caused samples of the water and ice to be analyzed.

The east branch of the Westfield River, above the point where the ice is collected, drains a very large and sparsely populated area; but a short distance above the mill pond from which the ice is taken there are two woodworking mills and a considerable number of houses, from which sewage is discharged directly into the river. The river at this point has a rapid current, and, on account of the small size of the mill pond, there is a rapid current through the pond itself.

The results of analyses of ice taken from the ice house in which the crop collected the past winter is stored show that the snow ice formed over the clear ice contains a much greater quantity of organic matter than is usually found in such ice; and even the clear ice formed beneath the snow ice also contains a considerably larger quantity of organic matter and a larger number of bacteria than are found in ice formed under favorable conditions. The ice also contained much foreign matter, which is probably due to the rapid flow of water through the pond at the time the ice was forming.

Considering the circumstances, the Board is of the opinion that this ice cannot be used with safety for domestic purposes where it may come in contact with food or drinking water.

Quincy.

MARCH 5, 1903.

To the Board of Health of the City of Quincy.

GENTLEMEN: — The State Board of Health received from you, on February 4, the following communication relative to a source of ice supply in the city of Quincy: —

Complaint has been made to our board of the unsanitary condition of the pond where the ice supply of the Meadow Brook Ice Co. is obtained on Wendall Road, this city. Will you please advise us in the matter? Our inspector finds that a bad odor came from the water of the pond.

In response to this application the Board caused one of its engineers to visit the city to examine the source referred to, who was informed that, instead of the Meadow Brook Ice Company's supply, your board wished an examination of the supply of the Crystal Spring Ice Company, and this source was accordingly examined and samples of the water and ice have been analyzed.

It appears from this examination that the water-shed of the pond from which the supply is taken consists largely of woodland, and that there are no places from which sewage or other polluting matter can enter the pond at the present time.

A sample of ice taken from the ice house near the pond was found, upon analysis, to be of excellent quality, and, in the opinion of the Board, ice taken from this source may safely be used for all domestic purposes.

The Board is unable to advise you as to the source of the odor noticed when ice was being harvested from this pond, but it is not unlikely that it was due to vegetable matter either in the water or on the bottom of the pond.

JAN. 7, 1904.

To the Board of Health of the City of Quincy, THOMAS J. DION, M.D., *Clerk.*

GENTLEMEN: — In accordance with your request of Dec. 16, 1903, the State Board of Health has caused the sources of ice supply used by the Meadow Brook Ice Company, the Eaton Ice Company and the Manet Spring Ice Company to be examined by one of its engineers and samples of the water of these sources to be analyzed.

At the time this examination was made it was not practicable to obtain ice from these sources for analysis, but a sample of ice said to have been harvested last year was taken from the ice house of the Meadow Brook Ice Company and analyzed. The pond from which the Meadow Brook Ice Company takes its supply is quite shallow over much of its area. The water-shed of Town Brook above the pond contains a large population, and the results of chemical analyses show that the water is considerably polluted. The sample of ice taken from the ice house near the pond was made up in part of snow ice, and this sample contained a larger quantity

of organic matter and a larger number of bacteria than are found in good ice. The clear ice appeared to be free from foreign matter.

Judging from the examinations thus far made, it may be practicable to obtain ice from this source which may safely be used for domestic purposes by removing from the ice, after harvesting, the first inch of ice that formed upon the pond and all snow ice or ice formed by flooding above the first inch, rejecting also all ice containing particles of foreign matter, and retaining only the clear ice beneath the first inch that forms upon the pond. Ice should be taken only from the deeper portions of the pond, where the bottom is free from weeds or other matters which might be included in the ice when freezing.

Furnace Pond, the source from which the Eaton Ice Company obtains its supply, is badly polluted by sewage and wastes from a large population on its water-shed, as is shown by the results of a chemical analysis of the water. An examination of the pond recently, when ice was forming, showed the presence of a large quantity of suspended matter both in the water and in the ice. In the opinion of the Board, it will be impracticable to secure ice from this source under present conditions which may safely be used in contact with food and drinking water.

The pond of the Manet Spring Ice Company at Hough's Neck contained very little water when examined, notwithstanding a heavy rain a short time previously, and the Board is unable to advise as to the probable quality of ice taken from this pond if formed at a time when the pond is filled with water. The exposed bottom of the pond when examined was covered with mud and organic matter, and a sample of water which had collected in a depression was found to contain a very large quantity of organic matter, which may have been derived from the bottom of the pond.

The Board would advise that a further examination of the ice of the Meadow Brook Ice Company and of the Manet Spring Ice Company be made at a time when ice is being harvested from these sources, to determine the condition of the ice at that time.

South Hadley (Charles Huot).

April 2, 1903.

To Mr. Willmore B. Stone, *Attorney* for Mr. Charles Huot, *407 Main Street, Springfield, Mass.*

Dear Sir: — On March 18, 1903, the State Board of Health received from you the following communication, relative to the use of ice from the ice pond of Charles Huot in South Hadley, Mass.: —

On Oct. 3, 1901, Charles Huot of South Hadley Falls submitted a plan for the improvement of his ice pond in South Hadley, and received from your Board on Nov. 7, 1901, certain advice relating thereto. Mr. Huot states that this advice has been complied with, and he has now on hand ready for market a large quantity of ice cut during the past winter from the pond, as improved.

He now desires that such inspection and test of this ice as may appear to your Board to be necessary be made, in order that he may be fully informed as to the suitability of the ice for sale for domestic use in the territory affording him a market therefor. He desires such inspection to be made as soon as convenient, and will afford every facility for obtaining samples of the ice and exposing the same to view.

Upon referring to the plan of Mr. Huot, concerning which the Board sent its communication of Nov. 7, 1901, referred to in your statement, it appears that this plan contained the following provisions: —

1. That our dwelling house and those in its immediate vicinity be connected with a sewer to be constructed in the highway in front of the houses, and all drainage from all the houses be discharged into such sewer. We understand this sewer is to be constructed at an early day, but in case it is not constructed, these houses are to be provided with absolutely tight cesspools and vaults, the accumulations in which shall never be allowed to overflow, but shall be removed and deposited on land outside the water-shed of the pond.

2. No fertilizing or manuring of the land forming the water-shed of the ice pond should be done before the first day of April nor after the first day of September in any year; and no fertilizing or manuring of any land located nearer than 300 feet from any water course or channel in which water is collected or through which water runs into the ice pond, should be done at any time of the year.

3. The keeping of pigs and cattle in barns or buildings or elsewhere on the water-shed should be discontinued, but cattle may be allowed to graze in the fields, provided they be not allowed to approach nearer any water course or channel through which wafer flows into the pond than 100 feet.

4. The pond should be entirely emptied and thoroughly cleaned by the removal of all muck and vegetable matter over the entire flowed area. The pond should be emptied every year by April first and not refilled for the winter before the fifteenth day of November. In cleaning the bottom of the pond, care should be taken to so deepen the edges of the basin that when the pond is flooded the water shall be at least 2 feet deep around the entire shore line of the pond. After the pond is thoroughly cleaned it should be kept clean, and every year the growths on the bottom should be removed late in the fall and just before the time of flooding (November 15) arrives.

5. No dumping of rubbish of any sort or kind should be permitted in or near any of the water courses or channels conveying water into the pond, and no wash from the highway, barn cellars or dooryards should be allowed to get into the pond.

The Board has caused a further examination of the pond to be made by one of its engineers, from which it appears that the proposed plans outlined above have not been carried out in several important respects. The dwelling houses in the immediate vicinity of the pond have not been connected with a sewer, neither are they provided with absolutely tight cesspools and vaults. Cesspools have been put in in the houses nearest the pond, but the examination showed obvious evidences that some of the cess-

pools had overflowed into one of the feeders of the pond, and nothing has been done to prevent the wash of the highway or drainage from the neighborhood of houses and barns on this water-shed from getting into the pond.

Samples of water have been collected from the three principal feeders of the pond, showing that two of these feeders are being very seriously polluted by sewage.

Two samples of the ice harvested from the pond during the past winter have been sent in by Mr. Huot, and other samples of the ice have been examined. The results of these examinations are similar to those of a previous examination. Some of the ice at present stored in the ice house beside the pond is of good quality, but portions of it are of poor quality, and the Board considers this ice unsafe to use where it may come in contact with food or drinking water.

STOUGHTON.

JULY 2, 1903.

To the Board of Health of the Town of Stoughton.

GENTLEMEN: — The State Board of Health has considered your request for an examination of the ice taken from the pond of the Stoughton Mills Corporation, formerly known as Consider Southworth's Pond, and has caused the pond and its surroundings to be examined and samples of the ice to be analyzed.

The water entering the ice pond in question is greatly polluted by sewage from the village of Stoughton and by manufacturing wastes from several factories.

The results of analyses of the ice taken from the ice house near the shore of the pond show that this ice contains a much larger number of bacteria than is found in ice from unpolluted sources, and, in the opinion of the Board, this ice cannot be considered suitable for domestic uses where it would come in contact with food or drinking water.

SEWERAGE AND SEWAGE DISPOSAL.

The following is the substance of the action of the Board during the past year in reply to applications for advice relative to sewerage and sewage disposal: —

BRIDGEWATER.

FEB. 16, 1903.

To W. F. WHITMARSH, M.D., *Chairman of Sewerage Committee, Bridgewater, Mass.*

DEAR SIR: — The State Board of Health received from you, on February 9, a request for further advice relative to a proposed system of sewerage and sewage disposal for Bridgewater, containing the following statement as to certain modifications in your proposed plans for disposing of the sewage: —

Acting under your advice, the committee has had its engineers prepare plans for disposal works in the valley of South Brook. The system as now designed

comprises two acres of filters instead of one as originally proposed, and, as the septic tanks have been eliminated, the system now offered will cost practically the same amount as the first plans submitted.

Owing to the small quantity of sewage which will have to be purified for several years, and also owing to the desirability of building as many street sewers as possible with the limited appropriation likely to be made for the whole sewerage improvement, it is earnestly requested that your Board sanction the plan for the construction of only two acres of filters at this time.

The advice of your Board is also sought relative to the desirability or prudence of postponing the adoption of a sewerage system by the town.

The engineer's plan is herewith submitted.

The Board has carefully considered your application and the plans now submitted for the disposal of the sewage, which provide for the construction of about six acres of sand filters, to be located in the valley of South Brook in the neighborhood of the works indicated in your former plans. By these plans the sewage from the main sewer is to be discharged into a dosing tank from which it is to be discharged intermittently on to the filter beds, the tank being emptied completely at each discharge. The general depth of sand in these filter beds is to be 4 feet, and underdrains are indicated to receive the effluent and discharge it into the brook.

The two acres of filters which it is proposed to provide in the beginning are to be divided into eight beds, each having an area of approximately one-fourth of an acre. The plan in general is, in the opinion of the Board, an appropriate one for the disposal of the sewage of the town, and it is probable that the two acres of filter beds arranged as now proposed will provide for the satisfactory purification of all the sewage of the town in the beginning, or until the sewers come into general use.

Regarding the importance of providing sewerage in the town, the Board would call attention to its communication of Jan. 3, 1901, a copy of which is enclosed herewith.

Chicopee.

June 26, 1903.

To Mr. James H. Loomis, *Mayor, Chicopee, Mass.*

Dear Sir: — In response to your application, received May 12, for advice relative to a proposed sewerage system for a portion of the city of Chicopee, the Board has caused the locality to be examined by one of its engineers and has considered the plan of sewerage which you have submitted.

The plan provides for a sewer about 2,000 feet in length to remove sewage and rain water from Academy and Front streets, and discharge it into the Chicopee River a short distance west of the electric light station, about midway between Chicopee Falls and Chicopee. This district is now sparsely settled, and the proposed sewer will provide adequately for the removal of sewage and storm water from the area which it is designed to serve at the present time. The flow of this sewer at times of storm may reasonably be discharged at the river bank, but provision should be made

for disposing of the dry-weather flow well away from the shore, by laying a small pipe from the bottom of the main sewer a short distance back of the principal outlet to a point of discharge in the river at least 50 feet from the bank. Several outlets of this kind may be seen in the city of Springfield.

While, under present conditions, objection is not likely to arise from the disposal of sewage into the Chicopee River at this place, it may become necessary in future to remove sewage from the stream on account of the use of the water for manufacturing or other purposes below; and in that case a large outlay might be required to separate the sewage from the storm water, as has been the case in several other cities in the State.

Considering these circumstances, it is advisable, in the opinion of the Board, to keep sewage separate from storm water wherever practicable. While, in this case, a separate system of sewers does not appear to be necessary at the present time, and would entail some extra expense, the Board would advise that house sewage be kept separate from roof water and other rain water and conveyed to the sewers by separate pipes, and such other provision be made as may be practicable to provide for the interception of the sewage proper from houses and other buildings and its removal by a separate system of sewers, if it should become necessary to do so at some future time.

EASTHAMPTON.

APRIL 17, 1903.

To the Board of Sewer Commissioners of the Town of Easthampton.

GENTLEMEN: — The State Board of Health received from you, on March 13, 1903, a communication requesting its approval of a system of sewerage and sewage disposal for the town of Easthampton, under the provisions of chapter 101 of the Acts of 1903, accompanied by a plan of the proposed system and outlets, by McClintock & Woodfall, civil engineers of Boston.

This plan shows the location of the proposed purification works as determined upon by investigations made about four years ago. Owing to the rapid growth of the town, the works proposed for the purification of the sewage at that time would not now be adequate; and the Board, therefore, requests that you submit a more complete plan, so as to show definitely the area and location of the proposed filter beds which you propose to construct for the purification of sewage. The area of filter beds that will be necessary will, of course, depend upon certain circumstances, such as the character of the soil and the proposed mode of treating and applying the sewage; but the Board would suggest that an area of not less than six acres be provided for, that is, an area of two and one-half acres in excess of that proposed in the plan of 1899 on file in this office, with opportunity for further extension indicated. When this plan is received the Board will act upon your petition relative to sewage disposal.

MAY 7, 1903.

To Messrs. JOSEPH H. SAWYER, ALBERT F. TOTMAN and GEORGE B. NOBLE, *Board of Sewer Commissioners of the Town of Easthampton.*

GENTLEMEN: — The State Board of Health received from you, on March 13, 1903, an application requesting its approval, under the authority of chapter 101 of the Acts of the year 1903, of certain alterations, extensions and improvements in the system of sewerage and sewage disposal of the town of Easthampton; and subsequently, on May 1, 1903, a plan was received showing existing sewers and the proposed alterations and extensions of the system. This plan is entitled "Town of Easthampton, Hampshire Co., Mass., System of Sewers, 1891–1903. Scale, 200 ft. = 1 in. McClintock & Woodfall, Civil Engineers, 15 Court Sq., Boston, Mass. Plan No. 1."

The plan shows a main sewer designed to intercept and receive the sewage of the main portion of the town and to convey it to the Manhan River at a point about 1,650 feet, measured along the stream, below the mouth of Broad Brook. You propose to discharge the sewage untreated directly into the river for a period of ten years, and subsequently to construct filter beds between the Mt. Tom Branch of the Boston & Maine Railroad and the Manhan River east of Broad Brook, and purify the sewage upon these filter beds; and you have presented a second plan, showing the proposed filter beds in detail, entitled "Proposed Sewage Filtration Area, Easthampton, Mass., 1903. Scale, 100 ft. = 1 in. McClintock & Woodfall, Engineers, 15 Court Sq., Boston, Mass. Plan No. 2."

The Board has caused the locality to be examined by its engineer, and has carefully considered your application and the plans submitted and the conditions affecting the disposal of the sewage of Easthampton. It appears, from the information furnished by you and an examination of the circumstances, that objectionable conditions now exist on account of the present disposal of sewage into Broad Brook, and that the removal of the sewage from that stream has become necessary.

In the opinion of the Board, if the sewage of Easthampton should be discharged into the Manhan River at the proposed point, a nuisance would be created in this stream below the outlet of your sewer. The Board does not approve that portion of your proposed plan which provides for the discharge of unpurified sewage into the Manhan River.

The portion of your plan which provides for the construction of filter beds between the Mt. Tom Branch of the Boston & Maine Railroad and the Manhan River east of Broad Brook presents a practicable method for purifying the sewage of the main portion of the town at a reasonable expense, and in such a manner as to remove objectionable conditions caused by your present method of sewage disposal, and prevent the creation of a nuisance elsewhere.

The Board hereby approves those portions of the proposed alterations,

extensions and improvements of your present system of sewerage and sewage disposal which provide for sewers to collect the sewage of the main portion of the town of Easthampton into a main sewer, running from the present main sewer near the upper end of the Williston Mills Pond to the proposed filtration area near the Manhan River, as shown upon plan No. 1, and approves the construction of filter beds at the places and in the manner shown upon plan No. 2; but does not approve the temporary outlet for sewage into the Manhan River, as shown on these plans, or any outlet for the discharge of crude sewage into Broad Brook or the Manhan River, except at the small outlet now existing into the Manhan River just below the water works dam for those buildings only which are adjacent to that portion of Northampton Street which lies between Main Street and the Manhan River.

Fitchburg.

Dec. 17, 1903.

To the Hon. C. H. Blood, *Mayor*, Messrs. W. T. Hall, *City Solicitor*, David A. Hartwell, *City Engineer*, and Messrs. G. H. Johnson, John Leiper, J. W. Merriam, W. H. Bennett and C. F. Cowdrey, *Special Sewer Committee of the City of Fitchburg.*

Gentlemen: — The State Board of Health received from you, on Dec. 2, 1903, plans of main trunk sewers with branches and of a system of sewage disposal for the city of Fitchburg, presented by your committee under the authority of said city, for the consideration and approval of this Board, under the provisions of chapter 354 of the Acts of the year 1901.

The plans, reports and descriptions submitted bear the following titles: —

No. 1. "Fitchburg Sewerage System. General Plan, showing Location of Trunk Sewer and Connections, Dec., 1903. Freeman C. Coffin, Civil and Hydraulic Engineer, 53 State St., Boston."

Note. — Main trunk sewer is shown by full red lines; connections are shown by dotted red lines; boundaries of districts are shown by dotted blue lines.

(The ground work of the above plan is a directory map of the city of Fitchburg for the year 1903.)

No. 2. "Fitchburg Sewerage System. Profile of Proposed Trunk Sewer from Waite's Corner to Filter Beds. Horizontal Scale, 1″ = 200′. Vertical Scale, 1″ = 10′. 1903. Freeman C. Coffin, Civil and Hydraulic Engineer, 53 State St., Boston."

No. 3. "Fitchburg Sewerage System. General Plan of Proposed Filter Beds. Scale, 1″ = 100′. Dec., 1903. Freeman C. Coffin, Civil and Hydraulic Engineer, 53 State St., Boston."

No. 4. "Special Report relative to Sewage Disposal in the City of Fitchburg, Massachusetts. Fitchburg Sentinel Printing Company, Printers, 1901."

No. 5. "City of Fitchburg. Report of the Joint Special Committee appointed February 8, 1903, on the Recommendations of the Mayor's Inaugural Address relative to Construction of a Portion of Main Trunk Sewer. Presented to the City Council September 8, 1903."

No. 6. "Brief Description of Connections to Trunk Sewer and Storm Overflows," by Freeman C. Coffin, Civil and Hydraulic Engineer, 53 State St., Boston.

Upon receipt of the application and plans above described, the State Board of Health, acting under the provisions of chapter 354 of the Acts of the year 1901, gave a hearing upon the proposed plans at its office, room 143, State House, on Dec. 17, 1903, after notice of the proposed hearing had been given by publication of such notice in newspapers published in the city of Fitchburg, and after notice in writing to the authorities of the towns of Leominster and Lunenburg.

The scheme, as presented in the above-described papers and at the hearing, is to collect the sewage of the city, which is at present discharged through twenty or more outlets into the north branch of the Nashua River, and the manufacturing wastes, excepting those from paper mills the wastes from which are to be treated locally, into two main trunk sewers, with branches, one of which will receive the sewage of the main portion of the city, while the other, designated as the South Fitchburg trunk sewer, is to receive the sewage of low areas in the south-easterly part of the city. These sewers are designed to convey the sewage by gravity to a filtration area located partly in the city of Fitchburg and partly in the town of Lunenburg, adjacent to the boundary line between these municipalities and the town of Leominster, where it is proposed to purify the sewage, after passing it through settling tanks, by intermittent filtration through filter beds of sand and gravel having an aggregate area of about 40 acres, and to discharge the effluent into the north branch of the Nashua River and into Baker's Brook, a tributary of the north branch of the Nashua River.

It appears that the present sewerage system of the city is constructed on the combined plan, so called, the sewers receiving both sewage and surface water, so that it is impracticable to convey all of the mingled sewage and storm water flowing in the present sewers at times of heavy rain or when snow is melting rapidly to the proposed filtration area and properly purify it there. The plan submitted provides for the separation of the sewage from the storm water in all of the area of the city now served by combined sewers, so called, by laying new drains in some streets and new sewers in others. It is proposed to separate the sewage from the storm water in a portion of the city in the beginning, including all of the district to be served by the South Fitchburg main sewer, and to carry out the separation in the remaining portion of the city by a gradual process of construction that will finally result in the complete exclusion of the surface water from the sewers; but, in making connections of tributary sewers with the main trunk sewer or its branches in districts in which the sewage has not been separated from the storm water at the time of the completion of the main trunk sewer and disposal works, it is proposed to provide storm overflows, so called, by which a part of the mingled sewage and storm water flowing in the present sewers at times of heavy rain or when snow is melting rapidly may overflow into the north branch of the Nashua River through the storm

overflows, and nine such storm overflows and outlets are indicated upon the plan submitted.

The plan of the proposed filtration area provides for receiving the sewage of the main trunk sewer in a settling tank upon the higher portion of the area, in which a portion of the solid matter is to be allowed to settle and to be drawn off upon sludge beds in the lower portion of the area. The sewage, after passing through the settling tank, is to be discharged upon the filter beds intermittently, and underdrains are to be provided, so far as necessary, to convey the effluent into Baker's Brook and the north branch of the Nashua River.

The South Fitchburg main sewer is to discharge upon filter beds in the low portion of the filtration area near the river, where the land is to be raised by filling with suitable material from the higher portions of the area.

After the hearing, at which no one appeared to oppose the plans presented, the Board considered the plans, and, instead of leaving the separation of the storm water from the sewage as a gradual process of indefinite extension by which sewage might enter the river through storm overflows for an indefinite period, the Board voted to modify the plans by limiting the time for completing the separation of the storm water from the sewage and of discharging sewage into the river to Jan. 1, 1915, after which date no unpurified sewage or manufacturing wastes are to be discharged into the river or any of its tributaries. As so modified and amended, the Board voted to approve the system of sewerage and sewage disposal as presented by the city of Fitchburg and as herein set forth.

Framingham (State Normal School).

Jan. 7, 1904.

To the State Board of Education, Mr. C. B. Tillinghast, *Acting Secretary.*

Gentlemen: — In response to your request of Dec. 16, 1903, for advice as to the disposal of sewage at the State Normal School at Framingham, the Board has caused the premises and the present method of sewage disposal to be examined by one of its engineers.

It appears from this examination that the sewage of the institution, together with the rain water from the roofs of some of the school buildings and condensing water from the engine room, is collected into a sewer which runs in a southerly direction to a filtration area near the Sudbury River, where the sewage, after passing through a settling tank, is applied to two filter beds of sand through pipes laid about 1 foot beneath the surface of the filters. The filters have an area of perhaps half an acre, and underdrains laid beneath the filters, about five feet below the pipes through which sewage is applied, convey the effluent to the Sudbury River.

This system, which was constructed about the year 1890, is said to have worked satisfactorily up to within about a year; but at the present time,

evidently on account of the clogging of the sub-surface distributing pipes through which sewage is applied to the filters, the sewage rises upon the surface of the filters and flows off the surface directly into the Sudbury River without purification. None of the pipes through which sewage is applied have been dug up, so that their condition and the general condition of the filter beds has not been ascertained, and it is not practicable to make a thorough examination of the condition of these filters at the present season of the year.

It is probable, in the opinion of the Board, that, by digging up the pipes through which sewage is applied and cleaning them, removing from the sand any material clogged by sewage, and subsequently relaying the pipes in a proper manner so as to allow sewage to pass out freely into the surrounding soil, the sewage of the school could again be purified on these filters; but, with this system of applying sewage, it will be necessary from time to time to dig up, clean and relay the pipes through which the sewage is applied, in order to maintain this system in successful operation.

The Board would advise that as soon as the frost is out of the beds the pipes through which sewage is applied to the filters be dug up, cleaned and relaid, and all clogged material that may be found about the pipes removed. The condition of the pipes in different parts of the beds should thereafter be inspected from time to time, and they should be cleaned and relaid when necessary.

It is unnecessary to discharge rain water from the roofs of the school buildings into the sewers, since this water can be allowed to flow off with the other rain water falling on the ground about the buildings, and its discharge into the sewers in large quantities may interfere with the successful operation of the sewage-disposal works. If, after digging up and relaying the pipes and diverting roof water and other rain water out of the sewers, the system is not found to work satisfactorily, it can be enlarged by the construction of additional filters upon the low land adjacent to the present filters.

Gardner (State Colony for Insane).

Oct. 1, 1903.

To the Trustees of the State Colony for the Insane, Gardner, Mass., Dr. Herbert B. Howard, *Chairman.*

Gentlemen: — The State Board of Health received from you, on September 15, an application for advice relative to plans of a proposed sewerage system for the State Colony for the Insane at Gardner, Mass., and subsequently a plan of the system was received from your engineer.

The plan provides for a system of sewers to collect the sewage from four buildings and convey it by gravity to filter beds south of the buildings, where it is proposed to purify the sewage by intermittent filtration, and discharge the effluent into a small brook.

The buildings for which it is proposed to provide sewerage at present

are to accommodate about 200 to 300 persons, and it is proposed to purify the sewage upon eight filter beds, having an aggregate area of about one acre.

The sewage is to be received at the filtration area into a settling or sludge tank, which will have a capacity of about 7,000 gallons, and will flow thence into a dosing tank having a capacity of 20,000 gallons, from which it is proposed to discharge it automatically through siphons to the filter beds.

The filter beds are to be constructed of sand $4\frac{1}{2}$ feet in depth above the bottom of the underdrains at the edge of the beds, and 5 feet in the middle of the beds, and are to be thoroughly underdrained. A bed is also provided for the disposal of the sludge from the settling tank.

The Board has caused the locality to be examined by one of its engineers and has considered the plans submitted, and is of the opinion that the proposed works are capable of removing and purifying efficiently all of the sewage likely to be discharged upon them from the buildings now in process of construction.

Haverhill.

Aug. 6, 1903.

To Hon. Parkman B. Flanders, *Mayor, Haverhill, Mass*

Dear Sir: — The State Board of Health received from you, on July 1, 1903, an application for advice relative to an outlet for the proposed new sewer in Mill Street, in which you give the following statement of your proposed plan: —

> The proposed sewer at its outlet is to be 36″ in diameter, and terminate at high-water mark or near it, and from a man-hole near the end of the main sewer a 15″ pipe surrounded with concrete is proposed for conducting the ordinary dry-weather flow to a point under water at the north edge of the channel, which at this point is very near to shore.
>
> It is proposed to first build the portions of the sewer above high-water mark, leaving suitable connections for the other portion, and later to construct the submerged portion, provided it shall be approved by you.

The application is accompanied by a plan and profile of the proposed outlet, showing the submerged outlet at a point about 60 feet from shore.

The Board has caused the locality to be examined by one of its engineers, and has carefully considered your application and the plan submitted therewith.

The Mill Street sewer, according to plans considered by the Board at a previous time, is to receive both sewage and storm water, including water flowing from Lake Saltonstall; and, since this sewer will drain a large district already quite densely populated, the flow of sewage in dry weather will be large.

The size of the proposed submerged pipe is ample for the dry-weather flow of sewage, and the plan is, in general, in the opinion of the Board, a suitable one for the disposal of the sewage of the Mill Street sewer. Sub-

merged outlets, similar to the one proposed in this case, have operated satisfactorily in other places, and will only occasionally require cleaning for the removal of sticks or similar matters brought down in the sewage.

The application states that it is proposed to build at first only the portions of the sewer above high-water mark; and, in accordance with this plan, the sewage would discharge at a point on the edge of the shore above high water until such time as the remainder of the outlet should be built.

The cost of the proposed submerged outlet will not be large, and there does not appear to the Board to be any good reason why this outlet may not be built in the beginning, with an overflow at the edge of the shore at high water for the discharge of the excess of flow at times of storm, until such time as the pier or wharf at the harbor line shall be built, when the overflow outlet may be extended to this point.

The present outlet discharges through a stone culvert near the level of high water, and at times of low tide the sewage spreads out over the beach between the sewer outlet and the water, producing very offensive odors and other objectionable conditions. There are several dwelling houses in the immediate neighborhood of this outlet. The new outlet, carrying a larger quantity of sewage, would undoubtedly cause a more serious nuisance than that which exists at the present time.

Under the circumstances, the Board would advise the construction of the submerged outlet in the beginning, and one of the many nuisances caused by the discharge of sewage along the river bank at Haverhill will then be removed.

HINSDALE (HINSDALE CREAMERY ASSOCIATION).

JUNE 4, 1903.

To the Hinsdale Creamery Association, MR. G. T. PLUNKETT, *President, Hinsdale, Mass.*

GENTLEMEN: — The State Board of Health received from you, on May 16, 1903, a communication stating that your association contemplates moving its plant from the present location in Hinsdale Center to a new location in Hinsdale, in order to secure better facilities for disposing of the wash water and to be nearer the railroad, and you desire advice as to the disposal of the wastes of the creamery.

It appears that two locations are under consideration, — one near the dam on the Housatonic River just below the central portion of the main village of Hinsdale, at which a grist mill is located, and the other near the bridge in the village a short distance up stream from this dam. If the creamery should be located at the first or lower location mentioned, the wastes would be discharged into the river below the dam at the grist mill, while at the upper location the wastes would be discharged into the mill pond above this dam.

In response to this application the Board has caused the present and proposed locations of the creamery to be examined by its engineer, and has considered the proposed plans for disposing of the wastes.

It appears that at present the wastes from the creamery, with the exception of the buttermilk, which is sold and removed, are discharged through a drain into a small brook, which also receives a small quantity of sewage from a hotel; and that the waters of this brook are very offensive at times of low flow to people living in its neighborhood just below the outlet of the drain from the creamery. While the sewage discharged into the stream doubtless assists in rendering the brook offensive, the creamery waste appears to be the chief cause of the present nuisance in the stream.

If the creamery should be removed to the location near the grist mill dam, in the main village of Hinsdale, and the waste discharged into the Housatonic River below this dam, the nuisance in the small brook would be avoided, and under ordinary conditions little if any nuisance would be caused by the disposal of creamery wastes into the river; but at times of dry weather, when no water is flowing over the dam at the grist mill, offensive odors might be noticeable in the neighborhood of the outlet. If the wastes should be discharged in deep water in the mill pond above the dam, and the mill pond kept nearly full, objectionable conditions about the outlet would probably be less noticeable.

The Housatonic River already receives much pollution from manufacturing waste at Hinsdale, especially from the mills just below the proposed point of discharge of the creamery wastes; and the effect of the discharge of these wastes into this stream without previous purification would be to increase the objectionable conditions existing there. Under the circumstances, the Board does not advise the discharge of the unpurified creamery wastes into the Housatonic River.

Experiments already made upon the purification of wastes from a similar creamery in another part of the State have shown that such wastes can be efficiently purified by filtration through sand; and, if the quantity of wash water does not exceed about 400 gallons per day, they can be purified efficiently upon a filter bed having an aggregate area of about 600 square feet, and containing gravel or coarse sand to a depth of from 2 to 2½ feet, with underdrains beneath the gravel or sand. If the quantity of the waste liquid is considerably less than 400 gallons per day, a smaller area than that indicated would be sufficient. The filter bed should be divided into at least two sections, and each section used on alternate days, and the wastes discharged upon different parts of the filter. If the wastes from the creamery should be applied to such a filter, properly cared for, they would be efficiently purified, so that they might be discharged into any of the streams about the village without causing offence.

There appears to be an opportunity for constructing such a bed near your present creamery at a reasonable expense, upon which all the creamery wastes could be discharged by gravity; and if purified in this way, the effluent flowing from the underdrains into the brook would not produce a nuisance. If the location shall be changed to either of the locations indi-

cated in the main village, it may not be practicable to discharge the wastes upon suitable filters by gravity; but if land can be secured farther down stream at reasonable expense, a satisfactory treatment of these wastes might be effected there by a filter bed such as has already been indicated.

HUDSON.

SEPT. 3, 1903.

To Messrs. GEORGE P. KEITH, TIMOTHY J. KEITH and JOSEPH JANDRON, *Sewerage Commission of the Town of Hudson.*

GENTLEMEN: — The State Board of Health received from you, on July 25, 1903, the following communication, requesting the approval by the State Board of Health of certain plans of sewerage and sewage disposal for the town of Hudson: —

In accordance with the provisions of section 2 of chapter 128 of the Acts and Resolves of Massachusetts, 1895, the undersigned beg leave to submit for your approval a system of sewerage and sewage disposal.

The proposed work is described in a printed report, and illustrated by five plans herewith presented. Our engineers will hold themselves in readiness to furnish additional information or to assist you in any way in considering the problem.

It is our intention to do some work this season, and we will greatly appreciate anything you can do to enable us to begin construction on some portion of the system at the earliest possible date.

The plans which you have submitted with the application are five in number, and bear the following titles: —

Sheet No. 1. "Town of Hudson. Plan of Proposed System of Sewerage and Sewage Disposal, January, 1903. Snow & Barbour, Engineers, Boston, Mass. Scale (graphical), $1'' = 206' \pm$."

Sheet No. 2. "Town of Hudson. Plan and Sections of Pump Wells and Station. Scale, $\frac{1}{4}'' = 1'$. January, 1903. Snow & Barbour, Engineers, Boston, Mass."

Sheet No. 3. "Town of Hudson. Plan of Pumping Station and Lot, January, 1903. Snow & Barbour, Engineers, Boston, Mass"

Sheet No. 4. "Town of Hudson. Plan of Disposal Plant. Scale, $1'' = 40'$. January, 1903. Snow & Barbour, Engineers, Boston, Mass."

Sheet No. 5. "Town of Hudson. Plan of Septic Tanks, January, 1903. Snow & Barbour, Engineers, Boston, Mass."

The plans provide in general for the collection of all of the sewage of the thickly settled portion of the main village of Hudson, including manufacturing wastes, at a pumping station to be located near the present electric light station on the north-westerly side of the Assabet River east of the village, from which the sewage is to be pumped to a filtration area located on the south-easterly side of the Assabet River east of Cox Street, where the sewage, after passing through a tank, is to be purified by intermittent filtration on filter beds of sand and gravel, and the effluent discharged into

the Assabet River. Twelve filter beds, having an aggregate area of about 6 acres, with underdrains to be laid from 5 to 6 feet beneath the surface of the beds for the removal of the effluent, are shown upon the plans, and other beds are indicated for future construction if found necessary.

In accordance with the provisions of chapter 128 of the Acts of the year 1895, a hearing was given by the State Board of Health at its office on Sept. 3, 1903, after fourteen days' notice by the Board of the presentation to it of the proposed system of sewerage and sewage disposal for the town of Hudson for its approval, by a publication of such notice in a daily and two weekly papers in the town of Hudson.

After the hearing the Board voted to modify and amend the plans of Hudson sewerage presented by you as follows: —

(1) By omitting from the plan the overflow well indicated at your pumping station, and providing instead a pipe extending from the chamber between the screen and the pump wells to the river, which shall be provided with a proper gate, to be operated by hand, which can be opened in case of emergency, such as an accident to the sewers, pumps, pumping station or force main, and at all other times is to be kept tightly closed.

(2) By removing the by-pass pipe, so called, leading from the dosing tank to the river, shown on sheet No. 4.

(3) By moving the filter beds north-easterly, so that no part of any filter bed shall be located within 200 feet of Cox Street, and no part of the tank within 300 feet of that street.

With these modifications and amendments, the first two of which are designed to prevent the discharge of any unpurified sewage into the river at any point, except that in case of emergency a gate operated by hand may be opened at the pumping station, through which sewage may be discharged if necessary, the Board approves the plans of sewerage and sewage disposal presented by you on July 25, 1903, as shown upon the five sheets with the titles as given herein.

The Board would add the following suggestions as to carrying out your proposed plans: —

The plans provide for the construction of underdrains beneath the sewers in wet places wherever practicable, to reduce the quantity of ground water, and for laying iron pipe with lead joints in places where there seems likely to be serious danger of the leakage of a large quantity of ground water into the sewers. These are important provisions, and should be carried out with much care, since by excluding ground and surface water a saving will be made in the cost of pumping and in the area of filter beds to be provided and cared for.

On account of the fact that the sewage will contain a large quantity of manufacturing waste, difficult of purification, such as wastes from wool scouring and from tanning, it is desirable that a large tank be provided at the filtration area, in which the sewage may be thoroughly mingled and a

portion of the solid matters separated from the sewage by sedimentation; but this tank should not be used as a septic tank, as proposed. The tank indicated on the plans is larger than will be required for the proper mixing and settling of the sewage in the beginning; but, as it is proposed to arrange the tank in three compartments, and such compartments as are not required can be shut off, there is no serious objection to providing a tank of this size. It is important, however, to avoid retaining the sewage in the tank for too long a time, since the sewage may in that case become very offensive, and may not subsequently be efficiently purified by the filters.

It is very important that an adequate pumping plant be installed and properly operated in the beginning; and the Board would advise that at least two pumps be installed, each of which is capable of pumping all of the sewage likely to be received at the pumping station at any time, so that repairs can be made to either pump when necessary without interfering with the operation of the works.

LANCASTER.

APRIL 2, 1903.

To the Board of Health of the Town of Lancaster, ALLAN G. BUTTRICK, A. E. HARRIMAN, C. C. BECKLEY.

GENTLEMEN: — The State Board of Health received from you, on March 7, an application for advice with reference to a proposed system of sewerage for a portion of the town of Lancaster, containing the following statement as to your proposed plans: —

This system is not a general one, and takes in the Lancaster Inn, Unitarian church, library, town hall and schoolhouse.

The proposed plan is to run a pipe down Main Street to the Nashua River.

The amount of sewage would be very small, as the inn is open only five months in the year; practically nothing would come from the church and library; and from the town hall and school building the amount would be but very little.

The Board has carefully considered your proposed plan, and the results of recent examinations of the conditions as to sewage disposal now existing in Lancaster.

It appears that the sewage of the buildings mentioned is disposed of at present by discharging it into cesspools, from which it overflows into a small brook, which at times of dry weather is very foul. The sewage of several private houses is also discharged into the same brook.

There is very great need of a sewerage system in the town of Lancaster, since it is evidently impracticable to dispose of the sewage satisfactorily by means of cesspools.

The Nashua River in the neighborhood of Lancaster is already grossly polluted by the sewage of the city of Fitchburg and the town of Leominster, and to discharge the sewage of Lancaster into the stream would further increase these objectionable conditions. In the opinion of the Board, the

further pollution of the Nashua River in the neighborhood of Lancaster should be prevented.

There is available land near the river, not far from the village, upon which it appears to be practicable to discharge the sewage of the town by gravity; and the next step for the town to take, in the opinion of the Board, is to cause a thorough study to be made and a plan to be prepared for the collection and disposal of the sewage of those portions of the town which are in need of sewerage or likely to require it in the near future, as you have already been advised to do in a previous communication from this Board, a copy of which is enclosed herewith.

When these studies have been made and the outlines of a general plan for the collection and disposal of the sewage of the town prepared, a partial system can then be constructed to serve the buildings mentioned in the application and other localities in need of sewerage.

When you have prepared a plan or plans for the disposal of the sewage of the whole or a part of the town, the Board will, upon request, advise you concerning them.

Lancaster (State Industrial School).

Jan. 7, 1904.

To the Trustees of the Lyman and Industrial Schools.

Gentlemen: — The plans of a proposed system of sewage disposal for the State Industrial School for Girls at Lancaster, prepared by Mr. J. J. Van Valkenburgh of South Framingham, and submitted by you on Dec. 21, 1903, have been considered by the Board. The plans provide for the collection of all of the sewage from the various school buildings into a settling tank, from which it is to be discharged upon six filter beds north-east of the school buildings, where the sewage is to be purified by intermittent filtration, and the effluent discharged into a small brook tributary to the Nashua River.

The location of the filter beds is remote from buildings, and, while it is not far from a highway, the filters will not be noticeable if trees and shrubs are planted near them to shield them from view. Material well adapted to the purification of sewage by filtration is found in the immediate neighborhood of the proposed filter beds, and the best practicable plan of disposing of the sewage is to construct filter beds upon the low land in the locality now proposed, by using sand from the higher lands near by.

The plans provide for laying a water pipe to connect with the sewer near the settling tank, so that water under pressure may be used for flushing the main sewer in case of necessity. The plans as a whole are, in the opinion of the Board, well adapted for the purpose; and, if the works are well built and properly maintained, they will provide satisfactorily for the purification of all of the sewage of the institution.

LENOX.

OCT. 1, 1903.

To the Board of Sewer Commissioners of the Town of Lenox.

GENTLEMEN: — By the provisions of chapter 271 of the Acts of the year 1886 the town of Lenox was authorized to construct a system of sewerage and sewage disposal, and in this act it is expressly provided that the town is not authorized to discharge its sewage unpurified into the Housatonic River or any tributary thereof.

A recent examination of your sewage-disposal system, by direction of the Board, shows that unpurified sewage is now being discharged directly into the Housatonic River near Lenox station on the New York, New Haven & Hartford Railroad. The Board calls your attention to this matter in order that the town may take such steps as may be necessary to purify the sewage before discharging it into the river or any of its tributaries.

LEOMINSTER.

NOV. 5, 1903.

To the Sewer Commission of the Town of Leominster, Mr. A. L. WHITNEY, *Chairman.*

GENTLEMEN: — The State Board of Health received, on Oct. 24, 1903, the following communication for advice with reference to a certain area of land in the town of Leominster which you are considering as a place of sewage disposal for the town: —

The town of Leominster, Mass., is considering the question of disposing of its sewage by intermittent sand filtration, and is having plans prepared to submit for your approval. In the mean time, we would like the advice of your Board relative to the location of the proposed filtration areas and the quality of the material to be used in their construction.

Test pits have been dug, and we would be pleased if you would make this investigation at your earliest convenience.

It appears that, so far as your plans have now been developed, it is proposed to bring all of the sewage of the town by gravity to an area of low land south-west of the Nashua River and north of Mechanic Street, upon which you propose to build filter beds of material to be taken from the adjacent high lands, and purify the sewage by intermittent filtration, allowing the effluent to flow into the north branch of the Nashua River.

In response to your application the Board has caused the locality to be examined by its engineer, and has considered the information at present available as to the collection and disposal of the sewage of the town.

The area indicated, while located at no great distance from the village, is in a sparsely settled portion of the town, and there is only one dwelling house in its immediate neighborhood. The location appears to be a desirable one, and, judging from present indications, the sewage of all of the

thickly settled portions of the town can be conveyed to this place by gravity, with the possible exception of a small low area in the immediate neighborhood of the Nashua River below the village of North Leominster. The character of the soil found in the higher lands bordering Mechanic Street, of which it is proposed to construct the filters, is excellent for the purpose, and filters which will efficiently purify the sewage by intermittent filtration can be constructed of this material; and there appears to be an ample quantity of material in these lands for the construction of a sufficient area of filter beds upon the adjacent low land to purify the sewage of Leominster.

So far as the Board is able to judge from the information now available, the plan of disposing of the sewage of Leominster by filtration upon the area indicated would be an appropriate one; but the Board is unable to give more definite advice until more definite plans, which you are now preparing, become available.

The Board is informed that many of the sewers now in use in the town receive both sewage and storm water. In making plans for a system of sewerage and sewage disposal, provision should be made for the separation of the storm water from the sewage, since the storm water, if unpolluted by sewage, can be readily disposed of into local water courses without objection. Adequate provision should also be made for receiving into the sewers and purifying all manufacturing wastes which may reasonably be disposed of in this way, in order that the further pollution of the streams in the town by these wastes may be prevented. It may be necessary in some cases, before receiving manufacturing wastes into the sewers, to provide for the removal of the heavier matters, which might cause trouble in the operation of the sewers or filter beds, and such provision should be made where necessary.

Manchester.

April 2, 1903.

To the Board of Health of the Town of Manchester, Mr. William H. Allen, *Secretary*.

Gentlemen: — The State Board of Health has considered your communication relative to the disposal of night soil in Manchester, in which you state that you have from 3,000 to 4,000 gallons per day of such material removed from cesspools and similar receptacles in the town, which is carried to various parts of the town — some dangerously near your sources of water supply — in carts or tanks owned by private parties; and you desire advice as to whether this material can be disposed of in a manner similar to the present method of disposing of the sewage of the Essex County Club at Manchester.

The Board has carefully considered your application and the conditions prevailing in the town, and the means available for the disposal of wastes from vaults and cesspools.

The soil in the thickly settled portions of the town appears to be of fine

and impervious character, so that cesspools require frequent cleaning to prevent overflow.

The system used for the disposal of the sewage of the Essex County Club is not adapted to the purification of the wastes collected from the various cesspools, etc., in the town, and it is impracticable to dispose of these wastes by this plan. It does not appear to be practicable to collect this material at any point in the town from which it could be conveyed out to sea and discharged there without serious danger of creating a nuisance.

The best plan for the town to adopt, under the circumstances, appears to be to collect all such material under its own supervision, in carts so constructed that no nuisance will be created in the highways, and to convey it to some area of land containing a coarse, sandy or gravelly soil, remote from dwelling houses, and at some place where no source of water supply will be affected, where this material can be discharged into trenches or pits prepared for the purpose and covered over with earth. If all the work is done in a careful and thorough manner, much of the offence attendant upon such a method of disposing of this matter can be avoided.

The conditions are such in the thickly settled part of this town that a sewerage system is greatly needed, and the Board would advise the town to take steps to provide a proper system of sewerage for those portions of the town which require it without delay, in order that the objectionable conditions attendant upon any method of disposing of wastes from vaults or cesspools may be avoided.

Marblehead.

June 4, 1903.

To the Committee on Sewerage of the Town of Marblehead, Mr. William J. Goldthwait, *Chairman.*

Gentlemen: — The State Board of Health received from you, on Feb. 14, 1903, an application for advice as to a proposed system of sewerage and sewage disposal for the town of Marblehead; and subsequently, on April 16, a report and plans of the proposed system and outlet were submitted by your engineer, together with the results of investigations as to the movement of floats in the waters between Gray's Rock and Peach's Point, west of your proposed outlet.

The plan in general provides for the collection of the sewage of the town into a main sewer, beginning in the south-westerly part of the town near the boundary line of the town of Swampscott, and running in a north-easterly direction near the sea shore and the shore of Marblehead harbor to a collecting reservoir and pumping station located on the shore of Little Harbor, near the gas works north of Fort Sewall, from which the sewage is to be pumped to a point of discharge into the sea about 200 feet south of Gray's Rock. The sewerage of the peninsula known as Marblehead Neck is provided for in these plans by means of a branch sewer laid along the harbor side of Marblehead Neck and through Beach Street to the main

sewer near the junction of Beach and Ocean streets at the westerly end of Marblehead Neck.

The Board has caused the locality to be examined by its engineer, and has considered the plans and the other information submitted therewith.

The system of sewerage provides for the collection of the sewage of all of the portions of Marblehead which are at present in need of sewerage or seem likely to require sewerage in the near future, with the exception of certain very small areas near the boundary line between Marblehead and Swampscott, from which it would be necessary to pump the sewage in order to discharge it into the proposed system; and it will probably be less expensive for the town to pump the sewage of these areas in future, when necessary, than to lay the main sewer at a sufficiently low level to receive the sewage by gravity. It may be possible to dispose of the sewage of these areas in connection with the sewage of adjacent areas in Swampscott at less expense than in any other way.

The slopes of some of the main sewers are smaller than desirable, and considerable care may be required to prevent deposits in them at times when the flow of sewage is small; but it would probably be less expensive to flush the sewers when necessary than to increase the slopes.

The location of the pumping station on the shore of Little Harbor, while not far from the thickly settled portion of the town, would not be objectionable.

It appears that all the floats used in the investigation for an outlet for the sewage were started from a spindle about a quarter of a mile from Peach's Point, and about half way between Peach's Point and the proposed outlet at Gray's Rock. The movements of floats started at this place show that the currents in the sea in this neighborhood are very weak, and that the movement of sewage would be controlled very largely by the direction of the wind; and the results of the investigations indicate that, if an outlet for the sewage should be located at this spindle, matters from the sewage might at times find their way to the shores of the mainland in the neighborhood. By locating the outlet at Gray's Rock, as proposed, the danger of floating matters reaching the shores of the mainland along the south-westerly side of the town would be considerably diminished; and it is probable that, if provision should be made for removing the larger objects at the pumping station, sewage might be discharged at this place in the beginning at least, and possibly for several years, without objection. The outlet would be located near the entrance to Marblehead harbor, however, and a large number of boats would pass in its neighborhood in the summer season, and it is desirable to locate it farther from shore, if practicable.

From a general examination of the locality and of the charts of the coast in this neighborhood, it appears that a satisfactory outlet for this sewage might be found off the south-easterly end of Tinker's Island, where it is possible that the currents would be more favorable to the removal and

complete dispersion of the sewage before it can come near any shore than would be the case at any point in the neighborhood of the mouth of Marblehead harbor that it is convenient to reach. It also appears to be possible to collect the sewage at a reservoir and pumping station in the neighborhood of the westerly end of Marblehead Neck; and the cost of works for disposing of the sewage at Tinker's Island might be no greater than in the neighborhood of Gray's Rock, while a more satisfactory outlet might be secured.

The Board would advise that, before deciding upon a plan of sewerage and sewage disposal for the town, you investigate the practicability of collecting the sewage near the westerly end of Marblehead Neck, and the movement of the currents off the south-easterly end of Tinker's Island. The Board would also advise that you make further investigations, by means of floats starting from the neighborhood of the outlet near Gray's Rock, as indicated on your plan, and from some point or points farther from the mainland, to determine more definitely the probable movement of sewage discharged in this neighborhood. When you have made further investigations the Board will, upon application, give you further advice as to the disposal of the sewage.

Newbury (Dummer Academy).

April 2, 1903.

To the Trustees of Dummer Academy, Byfield, Mass.

Gentlemen:—In response to your application for advice relative to the disposal of the sewage of the buildings at Dummer Academy by means of a sewer discharging into Mill River, a tributary of the Parker River at a point east of Newburyport turnpike, the Board has caused the locality to be examined by one of its engineers, and has considered the requirements of the institution and the probable effect of the sewage on the stream.

It appears from this examination that the Parker River, into which the sewage would find its way, is used as a place of storage for oysters, and that large numbers of clams are taken from the flats in this river in summer and considerable numbers at other seasons of the year. If sewage should be discharged into Mill River, as proposed, there would be danger that the shell-fish would be affected, and sickness caused thereby among those who might use the shell-fish for food.

In providing a system of sewage disposal for the academy buildings, it will be necessary, in the opinion of the Board, that the sewage be purified before turning it into Mill River or any tributary thereof. The quantity of sewage is small at the present time, and can doubtless be effectually purified by the construction of sand filter beds 5 feet in depth, having an aggregate area of about 1,200 square feet. If the sewage is turned on to these beds intermittently, changing the flow from bed to bed each day, the effluent, after passing through the sand filters, may be allowed to discharge into the stream.

Northampton.

Jan. 16, 1903.

To the Board of Sewer Commissioners of the City of Northampton.

Gentlemen: — The State Board of Health received from you, on Dec. 31, 1902, the following petition for an extension of the time for the removal of the sewage of the city of Northampton from Mill River, which, in a communication from this Board dated March 22, 1889, was limited to March 22, 1899, and subsequently extended to Dec. 1, 1903: —

> The sewer commissioners of Northampton, together with the mayor and city council of Northampton, respectfully petition your Honorable Board to permit so much of the sewage of the city of Northampton as comes from that part of the city south of Mill River, except that from the insane hospital, to be discharged into Mill River as at present for ten years, or until further order of your Honorable Board. They further ask your Honorable Board to extend to Dec. 1, 1904, the time for building a trunk sewer to the Connecticut River to carry the sewage from the north side of Mill River and from the insane hospital; and to allow the city ten years in which to do away with storm water overflows into Mill River from house sewers.

The State Board of Health, having considered the circumstances, hereby extends the time within which the sewage of the portion of the city of Northampton north of Mill River, including the sewage of the insane hospital south of the river, excepting such sewage as may pass through storm overflows at times of rain or when snow is melting, shall be removed from Mill River, to Dec. 1, 1904; and limits the time within which the remainder of the sewage south of Mill River and sewage from other sewers in the city flowing through storm overflows at times of rain or when snow is melting must be removed from that stream to ten years from the date hereof, unless, in the opinion of this Board, the public good shall require its earlier removal.

Nov. 5, 1903.

To the Board of Sewer Commissioners of the City of Northampton.

Gentlemen: — The State Board of Health received, on Sept. 29, 1903, the following communication from your engineer, describing proposed plans for a main sewer to convey the sewage of the city of Northampton from its present outlet in Mill River to an outlet into the Connecticut River: —

> I present herewith three plans from the Northampton sewer department, by the authority of the sewerage commission of the city of Northampton, asking for your approval of the proposed trunk line sewer extension from Pleasant Street to the Connecticut River, as shown on said plans.
>
> Plan No. 1 shows a general plan of the city of Northampton, with the present sewers, sizes and grades shown thereon.
>
> Plan No. 2 shows a plan of the section from Pleasant Street through the road leading to Hockanum Ferry and the proposed outlet at the Connecticut River; and also the profiles showing the present grade of the street and lands crossed

by the proposed trunk line, and the size and grade of the sewer proposed. It provides for a 48″ circular brick sewer from Wright Avenue to Williams Street; a 54″ circular brick sewer from Williams Street to the point on Pleasant Street where the present main sewer leaves the street and runs to the outlet at Mill River. From this point for about 847 feet a 60″ circular brick sewer is proposed, and from this last point a 66″ circular brick sewer to the man-hole on the bank of the Connecticut River; and from this man-hole to a point about 200 feet into the river it is proposed to lay a cast-iron pipe 66″ in diameter.

Plan No. 3 shows the cross-section of the river at the point opposite the proposed outlet of sewer, and the result of float experiments made within the past few weeks at a time when the water level was practically the lowest during the year. At the outlet, the iron pipe from the man-hole is to be directed down stream, as shown on plan, in order to avoid so far as possible any possibility of being disturbed by floating logs or other material in the river.

It is asked that you give these plans your consideration at as early a date as possible.

This application was accompanied by a plan of the sewerage system of the city, a plan and profile of the main sewer, and by a diagram showing the results of investigations of the currents of the Connecticut River by means of floats. You have also filed a copy of votes of your commission approving the plans as submitted to the State Board of Health.

The plans provide for a main sewer beginning at a point about 120 feet north of the centre of Holyoke Street, and extending through Pleasant Street and the road to Hockanum Ferry to an angle in the road within about a quarter of a mile of the ferry, at which point the line of sewer leaves the road and continues to the west bank of the Connecticut River, at a point about 460 feet south of Hockanum Ferry, and thence into the river to a point 160 feet from the present bank of the river at low water.

The Board has caused the locality to be examined by its engineer, and has considered the plans and information submitted therewith, and hereby approves them as a part of the Northampton sewage disposal system.

The plans of the location of the main sewer and outlet herein approved bear the following titles: —

1. "Northampton Sewer Dept. Plan of Sewers constructed to July 1, 1903. Scale, 1″ = 400′. M. D. Patteson, C.E."

This plan shows the location of possible future connection from sewers south of the river to the proposed main sewer in Pleasant Street, about 120 feet north of Holyoke Street.

2. "Northampton Sewer Dept. Trunk Line Sewer Extension. September, 1903. Ernest W. Bowditch, Consulting Engineer, Boston, Mass. M. D. Patteson, Civil Engineer, Northampton, Mass. Scale of Profiles: Horizontal, 40 feet to an inch; Vertical, 6 feet to an inch. Scale of Plan: 300 feet to an inch."

Pittsfield.

Oct. 1, 1903.

To the Board of Public Works of the City of Pittsfield.

Gentlemen: — On May 12, 1891, the State Board of Health approved a general plan for a system of sewerage and sewage disposal for the city of Pittsfield, providing for the permanent disposal of the sewage and factory waste or refuse by intermittent filtration, and allowing a temporary discharge of the sewage into the Housatonic River at a given point during the construction of the works, such discharge not to continue after June 1, 1900. Subsequently the time within which the sewage was to be removed from the river was extended, and in the year 1902 you completed works for the removal of the sewage discharged from the east side and west side intercepting sewers to filter beds in the southerly part of the city, where the sewage is now being purified by intermittent filtration.

A large outlay has been made by the city in providing works for the purification of its sewage and the prevention of the pollution of the river, and the disposal works already built are of sufficient size for the removal and purification of all of the sewage of the city at the present time. These works do not, however, receive all of the sewage discharged from the sewers of the city shown on the plan of sewerage approved by the Board in 1891. There remains within the limits of the sewered district included in that plan a considerable territory from which sewage is now being discharged into the Housatonic River, chiefly from the West Housatonic Street drain, which receives a quantity of sewage amounting to about one-fourth of the sewage of the city. While this large quantity of sewage continues to pollute the Housatonic River, the provisions of the plan of sewerage and sewage disposal presented by the city of Pittsfield and approved by the Board in 1891 are not being carried out, and the advantages of the work thus far done for the removal of sewage from the river are not being realized.

The sewage now being discharged directly into the stream comes chiefly from old sewers, which were built to remove both sewage and storm water. In a considerable portion of the area formerly served by combined sewers the sewage has been separated from the storm water, and it will not be difficult to separate the sewage from the storm water in the remaining portion of the areas now served by combined sewers, and to complete the work of removing the sewage from the Housatonic River by discharging all sewage into the city sewerage system. The storm water and ground drainage, if unpolluted by sewage, can be allowed to discharge into local water courses at the most convenient places.

The Board calls attention to these facts in order that the necessary steps may be taken by the city to complete the removal of the sewage from the river, in accordance with the provisions of chapter 357 of the Acts of the

year 1890 and the provisions of the plans approved by the State Board of Health under that act.

The plan for the sewerage of the city, approved in 1891, included the collection and disposal of objectionable manufacturing wastes, and it appears that the factories within the area included in that plan are connected with the system. A short distance beyond the limits of your present sewers, especially in the valley of the west branch of the Housatonic River, a great amount of pollution, chiefly from woolen mills, is discharged into the stream, and causes very objectionable conditions. Sewers should be extended to receive the objectionable wastes from these factories and the sewage of the thickly populated areas near them, and the pollution of the streams prevented.

Revere.

April 2, 1903.

To the Special Committee on Sewer Extension of the Town of Revere.

Gentlemen: — The State Board of Health received from you, on March 10, an application for advice relative to a proposed system of sewerage and sewage disposal for the town of Revere, accompanied by plans and a general description of the proposed system and outlets. The plan proposed is to construct sewers to convey the sewage from the two principal existing sewer outlets, one discharging into the sea off Cherry Island Bar and the other into Sales Creek, together with all of the sewage of the southerly and central portions of the town, and convey it to a proposed extension of the metropolitan sewer at the boundary line between Chelsea and Revere at or near Bay View Street. Two main sewers will be required for the collection of the sewage under this plan, one to receive the sewage of the southerly and easterly portions of the town, much of which now discharges at Sales Creek or Cherry Island Bar, and the other to take the sewage of the central and northerly portions of the town, which are now without sewerage facilities.

The latter sewer can be so laid that it will be capable of receiving by gravity the sewage of North Revere, so called, the extreme north-westerly section of the town north of the Pines River, and of the Point of Pines, so called, that is, the extreme north-easterly section of the town along the sea coast north of Oak Island, so that the two main sewers would furnish a gravity outlet for the sewage of all portions of the area of the town which are habitable at the present time. If, however, the North Revere and Point of Pines districts should be omitted from the plan, a saving of about $30,000 could be effected in providing sewerage for the present needs of the thickly populated parts of the town by laying the main sewer for the central and westerly portions of the town at a higher level and a steeper grade; and you desire advice as to whether provision should be made for taking the sewage of North Revere and the Point of Pines into the proposed main system by gravity, or whether the sewage of these small areas may be disposed of into adjacent tidal waters.

The Board has carefully considered your application and the plans submitted therewith, and has considered the requirements in respect to sewerage of the various portions of the town of Revere and the possible means of disposing of the sewage. In the opinion of the Board, the general plan now proposed for disposing of the sewage of Revere by discharging it into the metropolitan sewerage system is the best that it is practicable to adopt.

The Point of Pines district is at present practically uninhabited during most of the year, but is a resort for considerable numbers of people during the summer, and some means of disposing of the sewage during this season seems likely to become necessary before many years. The quantity of sewage is likely to be small, however, and it may be found practicable to dispose of it without serious objection for several years into the adjacent waters. If this should not be deemed a suitable or proper method of disposing of this sewage when sewerage for this district becomes necessary, it might be collected and pumped into the nearest available sewer of the town tributary to the general system.

The territory of North Revere is not at present in need of sewerage, and it may be many years before sewers will be required in this section. The Pines River is not, in the opinion of the Board, a suitable place in which to dispose of this sewage unless it is efficiently purified. It will probably be practicable, when sewers are required in this section, to collect the sewage at some convenient point and pump it into the nearest available sewer in the main system of the town. It may also be practicable to dispose of the sewage of this section of the town in connection with the sewage of adjacent sections of Malden or Saugus when sewerage becomes necessary in those districts.

Considering all the circumstances, the Board is of the opinion that the sewerage of the North Revere and Point of Pines districts may reasonably be omitted from the present plan, and the main sewer for the easterly and central portions of the town be laid at the higher level proposed. Since it may be desirable to pump the sewage of these areas into the main system of the town at some future time, it is important, in constructing or extending the main sewer and its principal tributaries toward the north-easterly and north-westerly sections of the town, to make provision in the sizes of the sewers, so far as practicable, for receiving sewage from these small areas if necessary.

Rutland (State Sanatorium).

Sept. 3, 1903.

To the Trustees of the Massachusetts State Sanatorium, Rutland, Mass.

Gentlemen: — The State Board of Health received from you, on Aug. 11, 1903, a communication stating that it is proposed to enlarge the sanatorium at Rutland so that it will contain a population in the future of about 450 persons, and requesting the advice of the Board as to removing the settling tank now in use in connection with the sewage-disposal system.

The Board has caused the locality to be examined by one of its engineers, and has considered the plans of sewerage and sewage disposal of the sanatorium in connection with the proposed increase in number of buildings and population.

It appears that the present main sewer is 10 inches in diameter, and is laid with a small slope for a distance of about half a mile from the buildings; and that beyond the end of this pipe the sewer is 8 inches in diameter, laid with a very steep slope leading down to an inverted siphon, which conveys the sewage across a valley and up to the filtration area. Experience has shown that the sewage contains few large objects or matters which would tend to clog sewers, and it is likely that the main sewer as now laid would operate satisfactorily without the use of the flush tank, though occasional flushing by means of hose might be found necessary or desirable. It is desirable, however, that a small tank be placed at the point where the iron pipe, which forms the inverted siphon, begins. This tank should be so arranged that its entire contents would be discharged through the siphon to the filter beds at each discharge of the tank, and a coarse screen should be provided to prevent large objects from entering the small pipe and passing to the siphon. If this arrangement should be made, there would be no objection to the removal of the present flush tank.

The present filter beds, if properly maintained, are capable of purifying all of the sewage of the institution, even with the enlargements now proposed. The filters have not received the necessary care in the past, and even at the present time they are not in as good condition as it is desirable to keep them. Notwithstanding the neglect of the beds, it does not appear that any unpurified sewage has been allowed to escape into the stream up to the present time; but it will be impracticable to properly purify the sewage of the institution, with its size increased as now proposed, upon the present filter beds, unless they receive proper care.

Rutland (Henry D. Chadwick, M.D.).

Dec. 3, 1903.

To Henry D. Chadwick, M.D., *255 Moody Street, Waltham, Mass.*

Dear Sir: — In response to your communication relative to the disposal of the sewage from your private hospital for treating tuberculosis at Rutland, the Board has caused the locality to be examined, and finds that the use of a cesspool at this place for the disposal of the sewage as proposed will not be likely to be successful in preventing unpurified sewage from escaping over the ground to Muschopauge Pond, the water supply of Rutland.

The sewage of the hospital, which you state is to accommodate about 15 patients, can be efficiently purified by discharging it upon prepared beds of sand or gravel, having a total area of about 2,000 square feet and a depth of filtering material of at least 4 feet. There does not appear to be any suitable material for the purification of sewage in the immediate neighbor-

hood of your proposed hospital, and it may be necessary to haul it for a considerable distance.

It is essential, if the hospital is to be used as proposed, that adequate provision be made for the purification of the sewage, in order to protect the purity of the water supplies taken from this region.

There are several similar private hospitals located in this region, where the conditions in regard to the disposal of sewage are somewhat similar, and the owners might save expense by collecting and disposing of all of the sewage at one place.

DEC. 3, 1903.

Mr. W. S. WINSLOW, Mr. J. S. HUNTRESS, Mr. DANIEL NYLAIN, Mr. CHARLES R. BARTLETT, *Rutland, Mass.*

DEAR SIR: — An examination of the present plan of disposing of the sewage from your buildings in Rutland, used as a private hospital for tubercular patients, shows that unpurified sewage therefrom is now finding its way into waters used as sources of public water supply.

The present method of disposing of the sewage of your hospital is contrary to law, and it is necessary that the sewage be either purified or removed to some point outside the water-shed of the south branch of the Nashua River or any of its tributaries in this region.

The Board would suggest that there are other similar places in this neighborhood where the present method of sewage disposal is objectionable, and there might be some saving in expense to each if all should combine and dispose of the sewage at one place.

DEC. 3, 1903.

Mr. A. F. BROWN, Mr. M. D. POTTER, *Rutland, Mass.*

DEAR SIR: — An examination of the present plan of disposing of the sewage from your buildings in Rutland, used as a private hospital for tubercular patients, shows that unpurified sewage therefrom is now finding its way into waters used as sources of public water supply.

The present method of disposing of the sewage of your hospital is contrary to law, and it is necessary that the sewage be either purified or removed to some point outside the water-shed of the south branch of the Nashua River or any of its tributaries in this region.

It is suggested that the sewage could be purified upon properly constructed filter beds of sand from 4 to 5 feet in depth, which would be capable of receiving from 1 to 1½ gallons of sewage per square foot per day if the sewage is applied intermittently.

SALEM.

SEPT. 3, 1903.

To the Salem Sewerage Commission, Salem, Mass., Mr. REUBEN AREY, *Secretary*.

GENTLEMEN: — The State Board of Health received from you, on July 25, the following application for the approval of plans of certain sewers in the city of Salem, under the provisions of chapter 353 of the Acts of 1901: —

Mr. Ernest W. Bowditch, the chief engineer of the Salem sewerage commission, is hereby authorized to present the plans showing the location of the proposed sewer from the point of discharge to a point north of Collins Cove, and such detailed plans as may be necessary, to the State Board of Health; and to apply, on behalf of the commission, for a hearing for the approval of said plans, in accordance with the provisions of chapter 353 of the Acts of 1901.

Motion by Mr. Doyle and seconded by Mr. Archer was duly passed and approved and referred.

R. AREY, *Secretary.*

SALEM, MASS., July 24, 1903.

On July 25 an application was made by Mr. Bowditch for a hearing, and a plan was presented by him showing a proposed North River intercepting sewer, beginning at the corner of Webster and Pleasant streets in Salem, and extending through Webster Street and along the northerly side of a branch railroad north of Webster Street in a south-easterly direction to Derby Street, and thence north-easterly to a pumping station located on the north-westerly side of Cat Cove, from which a main outfall sewer is shown extending to a point on the south-easterly side of Great Haste Island in Salem harbor. Profiles of the North River intercepting sewer, the trunk sewer and the main outfall sewer were also submitted with the application.

The plans provide for pumping all of the sewage to the outfall continuously as rapidly as it is received at the pumping station, and for the discharge of all of the sewage which may be received into these sewers at the outlet in Salem harbor near the south-easterly side of Great Haste Island.

In accordance with the provisions of chapter 353 of the Acts of the year 1901, a hearing was given by the State Board of Health at its office on Aug. 6, 1903, and on Sept. 3, 1903, after notice by the Board of the presentation to it of the plans of the proposed sewers and proposed location of pumping station and outlet for its approval, by the publication of such notice in three newspapers published in the city of Salem. The State Board of Health, having heard the evidence presented and having considered the proposed plans, hereby approves the construction by the city of Salem of the proposed North River intercepting sewer, the proposed trunk sewer, outfall sewer and the location of the pumping station, as shown upon the plans submitted to the Board on July 25, 1903, bearing the following titles: —

1. "Salem, Mass., Sewerage. Plan showing General Location of Proposed Outfall and Portion of North River Trunk Sewer, compiled from Various Sources, July, 1903. Ernest W. Bowditch, Chief Engineer, Boston, Mass. (Graphical scale, approximately 428.5′ to 1″.)"

2. "Salem, Mass., Sewerage, July, 1903, Ernest W. Bowditch, Chief Engineer, Boston, Mass. Profile North River Intercepting Sewer. Scales: Horizontal, 1″ = 40′; vertical, 1″ = 4′."

3. "Salem, Mass., Sewerage, July, 1903, Ernest W. Bowditch, Chief Engineer,

Boston, Mass. Profile Trunk Sewer. Scales: Horizontal, 1″ = 40′; vertical, 1″ = 4′."

4. "Salem, Mass., Sewerage, July, 1903, Ernest W. Bowditch, Chief Engineer, Boston, Mass. Profile for Proposed Main Outfall, compiled from Various Sources. Scales: Horizontal, 1″ = 200′; vertical, 1″ = 10′."

The plan approved provides for the discharge of all of the sewage which may be received into the above-described sewers or any of them at the outlet into Salem harbor near the south-easterly side of Great Haste Island, and at no other outlet.

SUNDERLAND.

JUNE 4, 1903.

To the Board of Selectmen of the Town of Sunderland, Messrs. F. L. WHITMORE, W. L. HUBBARD and C. M. HUBBARD.

GENTLEMEN: — The State Board of Health received from you, on April 28, 1903, an application for advice with reference to a proposed system of drainage and sewerage in the town of Sunderland, containing the following outline of your proposed plan: —

The proposed system of drainage and sewerage provides for two branches of vitrified pipe of from 10″ to 15″ in diameter, and with grades of from .3 to .2 of a foot per 100 feet, with the necessary number of street inlets for surface water and branches for the connection of house drains and sewers. Man-holes and lamp holes will be placed on the lines at intervals. Each branch will be on the easterly side of the street, and will be about ½ a mile long, with grade falling toward centre. At their junction a man-hole will be placed, and from this point the drainage will be carried to the Connecticut River by an 18″ vitrified pipe, about 1,100 feet distant; this will have a grade of .35 of a foot per 100 feet. At the outlet of the 18″ pipe for a distance of about 10 feet from the end an up grade of about .5 of a foot will be made to the end of the pipe, which will be set in masonry, and be some feet lower than the high-water mark of the river. At the lowest point of the 18″ pipe, that is, at about 10 feet from the place of discharge, connection will be made with a 6″ cast-iron pipe, extending downward toward the river and discharging near low-water mark. About 200 feet of cast-iron pipe will be used. The purpose is to carry the small amount of house sewage through this to low water, while, when any large amount of storm water is being disposed of, it will leave the upper outlet. The outlet for storm water will be several feet lower than the outlet to present drain under State highway.

The Board has caused the locality to be examined by its engineer, and has considered your proposed plan and the available information as to the requirements for sewerage and drainage in Sunderland. It is evident, from the information submitted to the Board, that a system of surface drainage is urgently needed for the main portion of the village of Sunderland, and there would be certain advantages in providing for both sewerage and drainage at the same time.

The main drains or sewers provided for in your proposed plan are not sufficient to remove water at times of heavy rains at as rapid a rate as it

will reach the sewers, and consequently water will accumulate upon the ground within the drainage district, and the sewers will be surcharged both during the rain and for a considerable time afterward. If provision should be made for taking sewage into these sewers, the mingled sewage and water would find its way back through the house connections, and cause much damage and offence unless all fixtures in the houses should be placed at a higher level than the water is likely to stand upon the ground in the drainage district; and if this should be done, the convenience and usefulness of the sewerage system would be greatly limited.

Near the extreme northerly end of the village, where your proposed drain is to begin, the street appears to be but little over 500 feet from the river, and the storm water from the northerly section of the village could apparently be drained into the river at this point without special difficulty. It also appears that there is a valley at the southerly end of the village into which it would be practicable to dispose of the drainage from that part of the village at some place not very far from the street. Drains for storm water only might be laid quite near the surface of the street, and, with two outlets at opposite ends of the town, instead of one, better grades might be secured and a larger quantity of storm water removed with pipes no larger than you now propose to use. A small pipe sewer might then be laid for the removal of the sewage, which could then be collected in a satisfactory manner, and might be discharged into the river at some suitable outlet.

Considering all the circumstances, the Board does not advise the adoption of your proposed plan for the drainage and sewerage of the village of Sunderland, but would advise that you give the matter further consideration, and prepare a plan providing for separate sewers for the sewage and for the drainage, since the conditions in Sunderland are such that a separate system for sewage and drainage is undoubtedly better for the town to adopt than the combined system now proposed.

The Board will, upon application, advise you as to any further plans for the disposal of the drainage or sewage of Sunderland that you may desire to present.

Walpole (F. W. Bird & Son).

May 7, 1903.

To Messrs. F. W. Bird & Son, *Walpole, Mass.*

Gentlemen: — In response to your request, received Jan. 7, 1903, for advice as to a plan of purification of wastes from your paper mill, the State Board of Health has caused an examination to be made of the experimental plant which you have recently put in operation.

The experimental plant consists of a cylindrical tank with a cone-shaped bottom, known as a "save-all," into which waste water from a paper machine is pumped for sedimentation, a portion of the water being drawn back to the paper machine from the bottom of the tank, and the remaining portion allowed to overflow from the top of the tank into the raceway.

Several chemical analyses have been made of samples collected by you and by the engineers of the Board, and the results show that the liquid returned to the paper machine from the tank contains a considerable quantity of pulp, which is thus kept out of the river; but, while the use of this machine evidently saves much valuable material that would otherwise be wasted, the amount of solid matter removed, as shown by the analyses, is only from 15 to 31 per cent. of the amount present in the liquid entering the "save-all," and the effect of using such tanks would not be likely to cause a very material improvement in the condition of the river below your factory.

It has been suggested that the waste waters now discharged into the river after passing from the "save-all" might be used in place of clear water now used in the operation of the paper machine. If this could be done, practically no waste from a paper machine would need to be discharged into the river. Considering the large quantity of water used in paper machines, a large gain would be made in dealing with the purification of the waste from your factory, if such a system could be placed in successful operation.

WELLESLEY (WELLESLEY COLLEGE).

APRIL 2, 1903.

To the Trustees of Wellesley College, Mr. ALPHEUS H. HARDY, *Treasurer, Wellesley, Mass.*

GENTLEMEN: — The State Board of Health received from you, on March 14, a communication requesting its advice relative to a proposed temporary sewage-disposal system for Wellesley College, and a general plan of the proposed system of sewerage and sewage disposal has been submitted by the superintendent of the institution.

The plan provides for the construction of a sewer to collect all of the sewage now discharged at your present disposal area in the northerly part of the college grounds and the sewage from other buildings in the grounds, and to convey it to an area near the junction of Waban and Fuller brooks, a short distance north of the point where the latter is crossed by the Sudbury aqueduct of the metropolitan water-supply district, where it is proposed to purify the sewage by filtration upon an area of about 4 acres. The plan provides for collecting the sewage in a settling tank having a capacity of about 17,000 gallons, from which the sewage will flow into a smaller tank, and thence be discharged intermittently through pipes laid beneath the surface of the ground from 8 to 12 feet apart. Several schemes for the distribution of the sewage through these pipes are suggested; one, by laying lines of tile pipes with open joints, through which the sewage may find its way into the soil; another, by providing branches in the pipes through which the sewage will discharge downward into circular holes filled with small stones to a depth of 1 foot; and a third, by laying the pipes upon broken stone in a trench 18 inches wide and 1 foot deep, into which the sewage will flow and thence find its way into the soil.

The Board has caused the locality to be examined by one of its engineers, and has considered the plans submitted for the disposal of the sewage.

The circumstances affecting the disposal of the sewage of Wellesley College are such that the best plan of disposing of the sewage in the future will be to discharge it into a general system of sewerage of the town, when such a system becomes available.

A plan of sewerage and sewage disposal prepared for the town of Wellesley, made under the direction of a sewerage committee and submitted to this Board last year, provides for collecting the sewage at some point in the valley of Fuller Brook, near the junction with Waban Brook, from which it is to be pumped to a disposal area in the north-westerly part of the town. The main sewer designed to convey all of the sewage from the college grounds to this neighborhood, therefore, can readily be connected with the general system of the town whenever such a system may be constructed, and this proposed main sewer will, if properly located and constructed, be of permanent value.

Much difficulty has been experienced in maintaining the present disposal works in the northerly part of the college grounds in proper condition; and the sub-surface distributing pipes through which sewage is distributed require cleaning and relaying from time to time. Owing to the objectionable conditions that exist here at times, and the nearness of the beds to proposed new buildings, it is desirable to use another area, if practicable. A part of the sewage is already disposed of upon lands near Waban Brook, adjacent to those which you now propose to use; and this area appears to afford the best practicable means available for the disposal of the sewage of the college until an outlet into a general sewerage system is provided.

While the information available as to the character of the soil of this area indicates that coarse and porous soil, suitable for the purification of sewage, is found here, it is important, in the opinion of the Board, before proceeding with the construction of the works, to make further tests of the soil by means of test pits, in order that information may be obtained as to the height of ground water in the soil, and that the filters may be constructed in soil which will readily absorb the sewage.

With regard to the plan suggested for the application of the sewage through pipes laid beneath the surface of the ground, your experience with the present disposal area in the northerly part of the grounds shows that the pipes clog, and require to be cleaned and relaid from time to time. If the sewage should be discharged into trenches or pits filled with broken stone, as suggested, clogging would not be avoided, and it would doubtless be necessary to relay the pipes and to clean or replace the broken stone from time to time, if this area should continue long in use. It would probably be best to lay the pipes upon porous soil beneath the loam and sub-soil at the surface, with coarse gravel surrounding the joints, graded so as to

prevent the entrance of fine material, and when clogging occurs to take up and relay the pipes in a new trench after cleaning them.

If the soil is somewhat fine, underdrains should be laid at least 4 feet below the pipes through which the sewage is applied, and at sufficiently frequent intervals to remove the filtered sewage readily without allowing the beds to remain saturated for a considerable time after the sewage is applied.

Westborough (Insane Hospital).

Nov. 5, 1903.

To the Trustees of the Westborough Insane Hospital, Westborough, Mass.

Gentlemen: — The State Board of Health has considered your communication of August 4, relative to certain changes in the method of disposing of the sludge or heavier matters from the sewage tank at the hospital, and your plans of works for the disposal of the sewage of two additional groups of buildings located near the westerly side of Chauncy Pond, which have been submitted by your engineer, and has caused an examination to be made of the present condition of the sewerage works.

The plan which has now been adopted, of conveying all of the sludge as well as the sewage to the filter beds and purifying it there, makes it practicable to prevent the further pollution of the brook by the escape of sludge and sewage from the sludge tank, and the arrangement made for disposing of the sludge at the filtration area is a satisfactory one.

The system of sewerage recently completed, by which the sewage of the new buildings is delivered upon the same filtration area as that used for the older buildings, is a satisfactory plan of disposing of the sewage of these new portions of the institution, and the filtration area is of ample capacity for the purification of all of the sewage now brought to it. When examined recently, a great improvement had been made in the condition of the beds, and their surfaces are now clean and free from the growths of weeds and grasses by which they were formerly obstructed. By maintaining the beds in their present excellent condition, it will be practicable to purify all of the sewage of the institution upon this area without causing objectionable conditions.

West Boylston (Worcester County Truant School).

Dec. 3, 1903.

To Mr. Frank L. Jones, *Superintendent, Worcester County Truant School, Oakdale, Mass.*

Dear Sir: — In response to your communication of November 5, the Board has examined the sewage filter beds at the school, but at the time no odor was noticeable. It is probable that odors will be less noticeable after the filter beds have been longer in use; and it is likely that, if a fence should be constructed along the northerly side of the filter beds, and trees planted there, odors from the works would not be perceptible from the

northerly side of the highway which passes between the filter beds and the school.

The Board has brought this matter to the attention of the Metropolitan Water Board, and is informed that the changes suggested will be made as soon as practicable.

Pollution of Ponds, Streams and Other Bodies of Water.

The following is the substance of the action of the Board during 1903 in reply to applications for advice relative to the pollution of ponds, streams and other bodies of water: —

Medway.

Aug. 6, 1903.

To the Board of Health of the Town of Medway.

Gentlemen: —In response to your request of June 24, 1903, for advice as to the best means of abating a nuisance existing in a canal in the village of Medway, the Board has caused the conditions to be examined by one of its engineers.

It appears from this examination that the nuisance is caused by the canal formerly used to convey water for power to a mill in the easterly portion of the village of Medway, but that, by the construction of a dam in the river near the lower end of this canal, the use of the canal has become unnecessary. The results of the examination of the locality show that the canal has been partially filled with earth at its lower end, and that much organic matter and refuse of all kinds has been thrown into its stagnant waters. The decomposition of this matter and the growth and decay of other vegetable and animal matters in the water are the probable causes of the nuisance, and the canal in its present condition is a menace to the health of the people living in this neighborhood.

The best and most effective method of preventing this nuisance, in the opinion of the Board, is to fill the canal with earth; and this method of removing the nuisance would not be a very expensive one, since the quantity of material required is not large, and suitable material can be obtained, apparently, near the canal. The Board would advise the adoption of this plan.

North Attleborough.

Jan. 7, 1904.

To the Board of Health of the Town of North Attleborough, H. C. Bullard, M.D., *Secretary.*

Gentlemen: — In response to your request for an examination of the condition of the Ten Mile River in North Attleborough, near which much sickness has recently occurred, and advice as to the prevention of the pollution of the stream, the Board has caused the locality to be examined by one of its engineers.

The results of this examination show that the Ten Mile River is used as a place for the disposal of sewage and manufacturing wastes by several large factories, employing in the aggregate more than 1,000 persons; and that in the lower portion of the village of North Attleborough the river is in a grossly polluted condition, and offensive even at this season of the year, when objectionable conditions are much less noticeable than in summer. It also appears that many cases of illness have recently occurred in the dwelling houses near the river in the lower portion of the village.

The nuisance in the Ten Mile River can be remedied by your board by action under the authority of chapter 75 of the Revised Laws; and there is no doubt that, if the pollution of the river by sewage and manufacturing wastes in North Attleborough should be prevented, the stream would not be objectionable, though it is desirable also that the channel of the stream, which is now obstructed in places, should be cleaned and put in proper condition.

It will undoubtedly be difficult to dispose satisfactorily of the sewage and manufacturing wastes now discharged into the stream, unless sewers shall be provided for the purpose. Sewerage is greatly needed in the thickly settled portion of the village, and the best plan of removing the objectionable conditions which now exist will be to construct such sewers as are now necessary to remove the sewage to a proper place of disposal. The sewers should be so constructed that they may be extended from time to time to serve other portions of the village; and it will be best to design a general system in the beginning, portions of which may be constructed as they are required.

NORTHBOROUGH.

JUNE 4, 1903.

To the Board of Selectmen of the Town of Northborough, MR. ALLYN D. PHELPS, *Clerk*.

GENTLEMEN: — The State Board of Health received from you, on March 13, a communication stating that part of the sewage of the Westborough Insane Asylum is finding its way into Little Chauncy Pond, and requesting the Board to investigate the matter; and in response to this request the Board has caused the locality to be examined by one of its engineers.

The results of the examination show that the solid matter collected in the settling tank used in connection with the sewage-disposal system of the hospital is discharged into a basin near the brook flowing from Chauncy Pond to Little Chauncy Pond, in which it is allowed to dry and is then removed in carts. The pollution of the stream is evidently caused at times by overflows from this basin, and the matter has been brought to the attention of the hospital authorities, who have been advised as to the prevention of further pollution of the stream.

WELLESLEY.

JUNE 4, 1903.

To Mr. GEORGE G. S. PERKINS, *Chairman, Board of Health, Wellesley, Mass.*

DEAR SIR: — In response to your application of Nov. 8, 1902, requesting this Board to take action as to the contamination of the waters of Lake Waban by refuse coloring matter and other wastes discharged from a factory located on a stream between Morse's Pond and Lake Waban, the Board has caused the locality to be examined, and has caused numerous analyses to be made of the wastes discharged into the stream and of the water of Lake Waban, to learn the effect of these wastes upon the water of the lake.

The results of the analyses show that a large quantity of refuse from the manufacture of paint, consisting chiefly of highly colored liquids, is discharged regularly into the stream and is carried into the lake.

The wastes from the factory contain much lead in solution, the quantity being so great during the past summer that the water in all parts of the lake was found to contain lead in such quantities that this water would be very injurious for drinking, and a considerable quantity of lead was also found in ice harvested from the lake.

Lake Waban is a tributary of the Charles River, above the filter-galleries of several large public water-supply systems which derive much of their water by filtration from the river, and such pollution is contrary to law. The great quantity of lead discharged with these wastes not only injures the water of the lake and the Charles River into which it flows, but also represents a large waste of valuable material by the factory.

The investigations by the Board indicate that it will be practicable to remove from these wastes much of the objectionable matter that now enters the lake. These facts have been brought to the attention of the owner of the factory, and the Board is informed that measures will be taken to keep these wastes out of the lake.

Under the circumstances, the Board will take no further action at the present time, but will make a further examination later in the year.

JULY 2, 1903.

To the Wellesley Park Commission, Wellesley, Mass.

GENTLEMEN: — The State Board of Health received from you, on May 13, 1903, a communication stating that your board has at various times found evidences of the contamination of Fuller Brook by the discharge of effluent from the sewage-disposal system of the Dana Hall School; and you request the advice of the Board as to the present condition of the effluent from that system, and whether it is endangering the stream into which it flows.

In response to this application the Board has caused the sewage-disposal

works of the Dana Hall School to be examined and samples of the sewage and effluent to be analyzed. The results show that the effluent which was being discharged into the stream from these works at the time the examination was made was not well purified, and, although a large portion of the organic matter was being removed from the sewage, the effluent was polluting the brook. Owing to the recent closing of the school for the summer season, it has not been practicable to make a more thorough examination to determine whether these works are capable of producing a well-purified effluent when treating all the sewage of the school; but it is probable that better results could be obtained by certain changes in the method of operation of the works, which the Board will indicate to the authorities of the school.

These works were constructed for temporary use only, pending the construction of a general system of sewerage for the town of Wellesley, which was being planned at the time they were built; but, while a suitable plan for the disposal of all the sewage of Wellesley was presented to the town some time ago, no further action has been taken toward the construction of a system.

Difficulty has also been experienced in the disposal of the sewage of Wellesley College, and there is evidently much need of sewerage in other parts of the town. Until a general system of sewerage is available, it will be difficult to prevent the increasing pollution of the streams in the thickly settled portion of the village, and it is not for the interests of Wellesley that such conditions should exist.

OCT. 1, 1903.

To the Board of Health of the Town of Wellesley.

GENTLEMEN: — In response to your application of September 14, for advice with reference to a proposed plan of abating a nuisance caused by a small area of wet, rotten and spongy land, including a small and shallow pond on the southerly side of Washington Street, east of Laurel Street in the village of Wellesley Hills, the Board has considered your plan and has caused the locality to be examined by one of its engineers.

It appears that the area is surrounded on three sides by higher land, but on the fourth side the land is low, and that a drain can be constructed from this side of the pond south-east to the head waters of Fuller Brook. It will be necessary to lay this drain over the top of the Cochituate aqueduct, and it appears that your surveys show that by a practicable location for the drain it will pass over the aqueduct at a level of about 1.5 feet below the surface of the pond.

The Board would advise that you drain the water in the pond as low as practicable without much expense, and that you fill up the area with coal cinders and other waste material.

Westborough (Insane Hospital).

June 4, 1903.

To the Trustees of the Westborough Insane Hospital, Westborough, Mass.

Gentlemen: — Complaint has been made to this Board that unpurified sewage from the sewerage system of the asylum finds its way into the stream flowing between Chauncy Pond and Little Chauncy Pond; and the Board, upon investigation, finds that a portion of the sludge from the settling tank used in connection with your sewerage system is at times allowed to escape into the stream.

The sewage-disposal system of the hospital is of ample capacity, so that no crude sewage need be allowed to discharge into any stream; and, unless sufficient care can be taken in removing the sludge from the tank, to avoid the pollution of any stream or pond, the Board would advise that the use of the settling tank be discontinued.

The filter beds used for the disposal of the sewage of the institution have not hitherto received proper care, but, on account of their large capacity for the purification of sewage, they have been able thus far to purify all of the sewage discharged upon them. The filter beds should be given proper care in the future. The solid matter which accumulates upon the surface of the beds should be removed as often as may be necessary; the surfaces of the beds should be raked after the removal of the solid matter, and the sewage should be discharged intermittently upon the beds, using each bed for not more than a day, instead of allowing the sewage to flow upon one bed for many days, as has been the case hitherto. If the filter beds receive proper attention, they are capable of receiving and purifying efficiently all of the sewage of the institution without the use of the settling tank.

Worcester.

March 5, 1903.

To Mr. N. J. Whittall, *Worcester, Mass.*

Dear Sir: — The State Board of Health received from you, on June 26, 1902, the following communication, relative to the pollution of Middle River in Worcester and objectionable conditions existing in that stream: —

I wish to bring before your Board a matter that is of great importance to my business and to the people in the section near my mills in Worcester.

My works at Worcester, consisting of six good-sized mills, employing over 1,000 hands, are located in South Worcester, so called, and are on a branch stream of the Blackstone River, called the Middle River. When the mills were established we had a fair water privilege and good clean water for dyeing and manufacturing purposes. This has been gradually deteriorating through the effect of other works up the stream emptying their refuse and sewage in it. There are large dye works which discharge all sorts of dyeing material; large cotton and woolen mills, using quantities of black preparations, copperas and vitriol, — all of which has made the water practically useless to us. This state of affairs was made much worse by the taking of a large part of the water

supply, the Kettle Brook system, by the city of Worcester some years ago, which very much reduced the volume of water, and consequently increased the evils, as the volume of polluting matter is as great or greater than ever, with only a small part of the water to take care of it.

Aside from the effects on our business, in my opinion it is dangerous to the public health. The smell along the stream is almost unbearable. It is having bad effect on our help, for we are constantly having cases of malarial sickness among the work people, and they are beginning to object to live in the vicinity of the mills. Unless we have some relief, we judge it may soon be difficult for us to obtain help.

After many complaints, extending over a period of years, the city of Worcester is at last preparing to clean out and fix up part of the river channel below our works along by my residence property, by which it seems matters there will be adjusted, with the exception of the smell, for this will not help us on the evils that come from above, in which we are mostly interested.

Now, I have invested a great amount of money in my plants here, besides having built a costly residence in the vicinity, and I think something should be done to abate these nuisances. For a number of years I have been bringing the case before all possible authorities, but without any satisfaction or redress. I now wish to ask if your Board can do anything for me, and if you can give me instructions as to what action to take.

Soon after this application was received the Board caused the locality to be examined by one of its engineers, and investigations were made as to the condition of the Middle River and Kettle Brook from above Cherry Valley to the Worcester precipitation works. It appeared from this examination that the stream received much pollution from factories and mills at many places; and later in the year the Board caused further and more thorough investigations to be made, including chemical analyses of samples of the water from many points on the stream from the neighborhood of Cherry Valley to the Worcester sewage precipitation works.

The results of these investigations show that Kettle Brook is very seriously polluted as it passes through Cherry Valley by sewage and manufacturing wastes from many factories and mills. Below Cherry Valley the stream passes through several ponds, and is joined in the neighborhood of Stoneville by two considerable tributaries from the south. It then passes through a series of ponds to Curtis Pond in Worcester. In the course of its passage from Cherry Valley to the outlet of Curtis Pond the condition of the stream greatly improves, and this pond was not materially affected, either in the appearance or odor of the water, at the time the examinations were made, by the pollution it received. Near the outlet of Curtis Pond the stream is polluted by sewage and manufacturing wastes from cloth washing and dyeing at the works of the Curtis Manufacturing Company; by sewage and wastes from dyeing and bleaching at the Worcester Bleachery and Dye Works; and, about a mile below Curtis Pond, by wastes from washing and dyeing woolen cloth at the Hopeville Manufacturing Company.

The most serious pollution of the stream, however, at the time these examinations were made, was caused by the sewage and manufacturing waste discharged from your factory. The water of the stream improves somewhat below this point down to the confluence of the stream with Mill Brook.

It is understood that sewers have become available for the reception and removal of sewage and manufacturing wastes from all but one of the factories below Curtis Pond, and that connections have recently been made with the sewers, by which some of the manufacturing wastes are now diverted from Middle River. It further appears that a sewer is likely soon to be available for the removal of the wastes from the remaining establishment. The owners of these establishments, by availing themselves of the means now provided for the removal of their wastes, can divert from the river the wastes which are now the chief cause of the objectionable conditions, and the city authorities possess ample power to secure the removal of the pollutions which now cause a nuisance in the stream.

Under the circumstances, it does not appear to the Board that further action on its part is necessary at the present time.

EXAMINATION OF WATER SUPPLIES.

EXAMINATION OF WATER SUPPLIES.

The systematic examination of the water supplies of Massachusetts has been continued throughout the year, and chemical analyses have been made of about 230 sources of public water supply. Microscopical examinations also have been made of nearly all of the samples from surface water sources which have been examined chemically. In the following tables a summary of the results of chemical examinations of sources of public water supply is presented, together with the results of examinations made in connection with advice to cities, towns, etc., with reference to proposed sources of supply. The results of the microscopical examinations have been omitted from this report.

Water Supply of the Metropolitan Water District.

During the year 1903 water has been supplied from the Metropolitan Water Works to the following cities and towns: —

City or Town.	Population in 1900.
Boston,	560,892
Somerville,	61,643
Chelsea,	34,072
Malden,	33,664
Arlington,	8,603
Quincy,	23,899
Everett,	24,336
Medford,*	18,244
Melrose,	12,962
Watertown,	9,706
Revere,	10,395
Winthrop,	6,058
Belmont,	3,929
Nahant,	1,152
Stoneham,	6,197
Swampscott,	4,548
Milton,	6,578
Lexington,*	3,831
Total population of cities and towns supplied,	830,709

* Partially supplied from local sources.

METROPOLITAN WATER DISTRICT.

In addition to the cities and towns included in the above table, a small portion of the town of Saugus has been supplied with water from the metropolitan works.

The principal source of supply of the district during the year has been Framingham Reservoir No. 3, which is supplied chiefly from the Sudbury Reservoir, which in turn receives through the Wachusett aqueduct the water of the south branch of the Nashua River. Water was drawn from this source each month during the year and from Lake Cochituate each month except August. Water was drawn from Framingham Reservoir No. 2 for short periods in May, June, August, September, October and December, and from Framingham Reservoir No. 1 in May and June.

The following statement in regard to the quantity of water drawn from the various sources is taken from the annual report of the Metropolitan Water and Sewerage Board: —

An average of 66,943,000 gallons per day was drawn from the south branch of the Nashua River through the Wachusett aqueduct into the Sudbury Reservoir, and an average of 92,675,000 gallons a day was drawn through the Sudbury aqueduct from Framingham Reservoir No. 3, which obtains its supply mainly from the Sudbury Reservoir. An average of 5,346,000 gallons per day was drawn through the Sudbury aqueduct from Framingham Reservoirs Nos. 1 and 2, which receive all of the water supplied from the main Sudbury River. A draft through Weston aqueduct from Sudbury Reservoir was started on December 29, amounting to an average of 209,000 gallons per day for the year. An average of 10,619,000 gallons per day was drawn from Lake Cochituate through the Cochituate aqueduct.

Chemical Examination of Water from the Sources of Supply of the Metropolitan Water District.

Quinepoxet River, Holden.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
Average of 6 samples collected in 1903,	.36	3.37	1.32	.0044	.0183	.0152	.0031	.36	.0052	.0001	.49	0.5
Average of eleven previous years,	.61	3.79	1.65	.0023	.0241	.0198	.0043	.23	.0054	.0001	.66	0.7

Stillwater River, Sterling.

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
Average of 6 samples collected in 1903,	.35	3.07	1.37	.0024	.0168	.0153	.0015	.18	.0017	.0001	.51	0.5
Average of eleven previous years,	.46	3.29	1.35	.0013	.0169	.0149	.0020	.16	.0036	.0000	.54	0.7

METROPOLITAN WATER DISTRICT.

CHEMICAL EXAMINATION OF WATER FROM THE SOURCES OF SUPPLY OF THE METROPOLITAN WATER DISTRICT — *Continued.*

South Branch of Nashua River, above Clinton.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
					Total.	Dissolved.	Sus-pended.					
Average of 12 samples collected in 1903,	0.33	3.38	1.35	.0020	.0158	.0133	.0025	.21	.0052	.0001	0.45	0.8
Average of nine previous years, . .	0.40	3.72	1.39	.0017	.0187	.0158	.0029	.22	.0055	.0000	0.47	1.1

Sudbury Reservoir, Surface.

Average of 12 samples collected in 1903,	0.26	3.71	1.41	.0025	.0139	.0119	.0020	.25	.0100	.0001	0.40	1.3
Average of five previous years, . .	0.26	3.82	1.36	.0026	.0165	.0138	.0027	.23	.0090	.0001	0.39	1.2

Sudbury Reservoir, Bottom.

Average of 12 samples collected in 1903,	0.27	3.81	1.35	.0033	.0133	.0115	.0018	.26	.0112	.0001	0.40	1.3
Average of five previous years, . .	0.27	4.09	1.43	.0045	.0149	.0132	.0017	.25	.0122	.0001	0.40	1.4

Framingham Reservoir No. 3.

Average of 12 samples collected in 1903,	0.25	3.83	1.35	.0027	.0138	.0117	.0021	.26	.0108	.0001	0.39	1.3
Average of five previous years, . .	0.25	4.01	1.39	.0020	.0165	.0140	.0025	.25	.0098	.0001	0.40	1.3

Indian Brook, at Head of Hopkinton Reservoir.

Average of 4 samples collected in 1903,	1.46	5.85	3.34	.0027	.0315	.0297	.0018	.45	.0025	.0000	1.51	1.3

Hopkinton Reservoir, Surface.

Average of 4 samples collected in 1903,	0.55	3.74	1.76	.0024	.0176	.0152	.0024	.30	.0035	.0000	0.70	0.6

Hopkinton Reservoir, Bottom.

Average of 4 samples collected in 1903,	0.51	3.50	1.55	.0027	.0145	.0132	.0013	.29	.0045	.0000	0.63	0.6

Cold Spring Brook, at Head of Ashland Reservoir.

Average of 4 samples collected in 1903,	1.46	5.61	3.04	.0021	.0334	.0307	.0027	.32	.0032	.0000	1.37	1.3

METROPOLITAN WATER DISTRICT.

Chemical Examination of Water from the Sources of Supply of the Metropolitan Water District — *Continued.*

Ashland Reservoir, Surface.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as			
					Albuminoid.							
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
Average of 4 samples collected in 1903,	.62	3.66	1.69	.0022	.0188	.0168	.0020	.25	.0020	.0000	.75	0.7

Ashland Reservoir, Bottom.

Average of 4 samples collected in 1903,	.56	3.40	1.54	.0031	.0169	.0150	.0019	.24	.0037	.0000	.68	0.8

Sudbury River, at Head of Framingham Reservoir No. 2.

Average of 4 samples collected in 1903,	.86	4.57	2.15	.0020	.0235	.0217	.0018	.36	.0042	.0000	.92	0.9

Framingham Reservoir No. 2.

Average of 4 samples collected in 1903,	.70	4.14	2.08	.0035	.0208	.0185	.0023	.31	.0047	.0000	.78	1.0

Lake Cochituate, Wayland.

Average of 12 samples collected in 1903,	.23	4.91	1.94	.0020	.0188	.0159	.0029	.46	.0077	.0002	.44	2.0

Sudbury Aqueduct, at Terminal Chamber, Chestnut Hill Reservoir.

Average of 12 samples collected in 1903,	.27	3.88	1.41	.0022	.0142	.0123	.0019	.27	.0113	.0001	.41	1.8

Spot Pond, Stoneham.

Average of 12 samples collected in 1903,	.08	3.72	1.31	.0018	.0149	.0126	.0023	.30	.0033	.0000	.26	1.5

Faucet at State House, Boston.

Average of 12 samples collected in 1903,	.25	3.98	1.50	.0013	.0125	.0110	.0015	.30	.0142	.0001	.39	1.5
Average of five previous years, . .	.28	4.01	1.46	.0011	.0148	.0131	.0017	.27	.0115	.0001	.40	1.4

METROPOLITAN WATER DISTRICT.

CHEMICAL EXAMINATION OF WATER FROM THE SOURCES OF SUPPLY OF THE METROPOLITAN WATER DISTRICT — *Concluded.*

Faucets in Revere.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as			
					Albuminoid.							
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
Average of 12 samples collected in 1903,	.08	3.83	1.25	.0015	.0141	.0114	.0027	.30	.0043	.0001	.26	1.6
Average of three previous years, . .	.13	4.11	1.33	.0013	.0148	.0132	.0016	.28	.0068	.0001	.32	1.7

Faucets in Quincy.

Average of 12 samples collected in 1903,	.24	4.12	1.51	.0010	.0122	.0110	.0012	.32	.0162	.0000	.37	1.6
Average of two previous years, . .	.24	4.12	1.53	.0010	.0143	.0126	.0017	.30	.0155	.0001	.40	1.6

WATER SUPPLY OF ABINGTON AND ROCKLAND. (See also page 5.)

Big Sandy Pond, Pembroke.

Average of 4 samples collected in 1903,	.13	3.24	1.14	.0015	.0131	.0116	.0015	.61	.0007	.0000	.22	0.5

WATER SUPPLY OF ADAMS FIRE DISTRICT.

Bassett Brook.

Average of 3 samples collected in 1903,	.03	3.47	0.93	.0007	.0037	.0034	.0003	.06	.0203	.0001	.14	2.4

Dry Brook.

Average of 3 samples collected in 1903,	.12	7.02	1.80	.0013	.0061	.0060	.0001	.10	.0077	.0002	.27	5.2

Tubular Wells at Cheshire Harbor.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 2 samples collected in 1903.	.00	13.30	-	.0002	.0006	-	-	.09	.0430	.0001	.03	11.1	.0050

ADAMS FIRE DISTRICT.

Waters examined in Connection with Advice Relative to the Use of Water from the Zylonite Wells in Adams. (See also page 6.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1903.												
48175	Nov. 20	None.	None.	.00	9.90	.0008	.0034	.07	.0300	.0000	.00	9.4	.0050
48176	Nov. 20	None.	V. slight.	.00	12.70	.0008	.0018	.09	.0420	.0001	.00	11.1	.0110

The first sample was collected from the wells; the last, from Bassett Brook Reservoir, which receives water from the wells.

WATER SUPPLY OF AMESBURY. — POWOW HILL WATER COMPANY.

Wells near Main Street.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 7 samples collected in 1903.	.08	10.59	-	.0033	.0023	-	-	0.95	.1110	.0004	.04	4.1	.0695

Wells near Market Street.

Average of 8 samples collected in 1903.	.01	25.90	-	.0039	.0029	-	-	1.29	.0051	.0001	.05	12.8	.0072

WATER SUPPLY OF AMHERST. — AMHERST WATER COMPANY. (See also page 7.)

Amethyst Brook Reservoir.

Average of 4 samples collected in 1903.	.24	3.11	0.99	.0014	.0083	.0072	.0011	0.12	.0042	.0000	.34	0.4	-
Average of three previous years, .	.46	3.49	1.51	.0027	.0176	.0159	.0017	0.14	.0035	.0001	.65	0.4	-

AMHERST.

Waters examined in Connection with Advice relative to Additional Water Supply.

(See also page 7.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1903.														
43726	Jan. 12	None.	V. slight.	.20	2.50	1.00	.0004	.0062	.0062	.0000	.12	.0010	.0000	.36	0.3
43727	Jan. 12	None.	None.	.10	2.40	0.80	.0008	.0052	.0048	.0004	.12	.0050	.0000	.24	0.3
43728	Jan. 12	None.	V. slight.	.10	3.45	0.90	.0158	.0072	.0050	.0022	.11	.0010	.0001	.13	1.4

The first sample was collected from the east branch of Nourse Brook, near the junction of the branches; the second, from the west branch of Nourse Brook, near the junction of the branches; the last, from Atkins' Pond.

Water Supply of Andover.

Haggett's Pond.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
Average of 4 samples collected in 1903,	.15	3.01	1.25	.0025	.0128	.0119	.0009	.31	.0022	.0000	.31	1.2

Water Supply of Arlington.

(See *Metropolitan Water District*, pages 138–141.)

Water examined in Connection with Advice to the Robbins Spring Water Company.

(See also page 9.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1903.												
45115	Apr. 27	None.	None.	.00	4.30	.0000	.0012	.44	.0220	.0000	.00	1.7	.0030

The sample was collected from the bottling house of the Robbins Spring Water Company.

ASHFIELD.

Ashfield.

Waters examined in Connection with Advice relative to a Proposed Water Supply.
(See also pages 9, 10.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1903.														
47253	Sept. 18	V. slight.	V. slight.	.35	4.50	2.00	.0012	.0150	.0144	.0006	.20	.0040	.0000	0.57	2.2
47338	Sept. 25	None.	V. slight.	.17	4.50	1.50	.0000	.0066	.0064	.0002	.10	.0060	.0000	0.26	2.7
47252	Sept. 18	None.	V. slight.	.72	5.30	2.75	.0012	.0248	.0240	.0008	.18	.0020	.0000	1.10	2.3
47337	Sept. 25	None.	V. slight.	.16	4.85	1.35	.0002	.0072	.0068	.0004	.11	.0010	.0000	0.28	2.9
47750	Oct. 23	None.	V. slight.	.20	4.65	1.05	.0000	.0058	.0054	.0004	.12	.0010	.0000	0.41	2.6
47339	Sept. 25	–	–	.20	–	–	.0010	.0064	–	–	.11	–	–	–	–
47749	Oct. 23	None.	V. slight.	.20	4.60	1.35	.0002	.0056	.0052	.0004	.11	.0010	.0000	0.40	2.6
47751	Oct. 23	None.	V. slight.	.10	3.30	0.80	.0002	.0048	.0046	.0002	.10	.0040	.0000	0.27	1.7
47748	Oct. 23	V. slight.	V. slight.	.10	4.60	0.80	.0014	.0152	.0120	.0032	.11	.0010	.0000	0.24	3.1

The first two samples were collected from Taylor Brook; the third, from the head waters of Stone's Brook; the fourth and fifth, from Bear Swamp Brook, at "Little Switzerland;" the sixth and seventh, from the northerly tributary of Bear Swamp Brook, above "Little Switzerland;" the eighth, from Creamery Brook, at the road crossing near its upper end; the last, from Great Pond.

Water Supply of Athol. — Athol Water Company. (See also page 11.)

Large Reservoir in Phillipston.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.			
Average of 4 samples collected in 1903.	.54	3.35	1.49	.0033	.0176	.0117	.0059	.12	.0035	.0000	.69	0.6	–
Average of nine previous years, .	.67	3.70	1.72	.0036	.0355	.0219	.0136	.14	.0056	.0000	.78	0.7	–

Buckman Brook Reservoir.

Average of 4 samples collected in 1903.	.41	3.76	1.54	.0030	.0224	.0151	.0073	.14	.0012	.0000	.67	0.8	–
Average of four previous years, .	.48	3.37	1.51	.0018	.0200	.0170	.0030	.12	.0043	.0000	.70	0.6	–

Water Supply of Attleborough. (See also page 12.)

Well.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.			
Average of 8 samples collected in 1903.	.02	3.78	-	.0015	.0041	-	-	.32	.0084	.0000	.10	1.5	.0069

Water Supply of Avon.

Well.

Average of 8 samples collected in 1903.	.00	3.94	-	.0003	.0010	-	-	.35	.0635	.0000	.01	1.1	.0047

Water Supply of Ayer.

Well.

Average of 9 samples collected in 1903.	.00	5.44	-	.0007	.0023	-	-	.41	.0403	.0000	.04	2.2	.0112

Barnstable.

Water examined in Connection with Advice Relative to a Proposed Water Supply. (See also page 13.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
45588	1903. May 27	None.	None.	.00	3.80	.0004	.0034	1.14	.0050	.0000	.02	0.2	.0080

The sample was collected from a tubular well, 100 feet from the shore of Wequaket Lake.

Water Supply of Belmont.

(See *Metropolitan Water District*, pages 138–141.)

Water examined in Connection with Advice to Delano Moore. (See also page 14.)

44460	1903. Mar. 6	None.	V. slight.	.00	4.50	.0000	.0018	0.24	.0040	.0000	.03	1.6	.0050

The sample was collected from a spring near Marsh Street.

BEVERLY.

WATER SUPPLY OF BEVERLY.

(See *Salem*.)

WATER SUPPLY OF BILLERICA.

Tubular Wells.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Sus-pended.						
Average of 10 samples collected in 1903.	.08	6.57	-	.0012	.0027	-	-	.26	.0065	.0000	.10	2.4	.0435
Average of four previous years, .	.05	6.32	-	.0006	.0022	-	-	.26	.0091	.0000	.06	2.2	.0230

BOLTON.

Water examined in Connection with Advice to Guy F. Emerson. (See also page 15.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
46199	1903. July 9	None.	V. slight.	.00	3.10	.0006	.0054	.15	.0150	.0000	.04	0.5	.0010

The sample was collected from a spring on land of M. H. Mentzer.

WATER SUPPLY OF BOSTON.

(See *Metropolitan Water District*, pages 138-141.)

WATER SUPPLY OF BRAINTREE. (See also page 15.)

Filter Gallery.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Sus-pended.						
Average of 9 samples collected in 1903.	.03	4.93	-	.0015	.0056	-	-	.83	.0405	.0000	.12	1.8	.0056

BRIDGEWATER AND EAST BRIDGEWATER.

Water Supply of Bridgewater and East Bridgewater. — The Bridgewaters Water Company.

Faucets in Bridgewater.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 8 samples collected in 1903.	.13	6.55	-	.0008	.0033	-	-	.46	.0215	.0000	.07	2.1	.0671

Water Supply of State Farm, Bridgewater.

Taunton River.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1903.														
45756	June 9	V. slight.	Slight.	0.78	4.85	2.25	.0052	.0212	.0180	.0032	.60	.0070	.0000	0.83	0.8
47122	Sept. 9	V. slight.	V. slight.	0.66	5.55	2.30	.0014	.0200	.0188	.0012	.79	.0200	.0002	0.81	1.0
Av.	....	....	....	0.72	5.20	2.27	.0033	.0206	.0184	.0022	.69	.0135	.0001	0.82	0.9
Average of 6 samples collected in 1902.				1.11	5.44	2.57	.0048	.0264	.0226	.0038	.60	.0132	.0002	1.11	1.0

Taunton River after Filtration.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1903.												
45757	June 9	None.	None.	.50	4.40	.0010	.0116	.60	.0100	.0000	.64	1.1	.0180
47125	Sept. 9	V. slight.	None.	.35	4.90	.0002	.0098	.74	.0180	.0000	.62	1.0	.0110
Av.	....	....	....	.42	4.65	.0006	.0107	.67	.0140	.0000	.63	1.0	.0145
Average of 6 samples collected in 1902.				.87	5.22	.0020	.0174	.61	.0188	.0000	.88	1.3	.0170

BROCKTON.

Water Supply of Brockton.

Salisbury Brook Storage Reservoir.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 12 samples collected in 1903.	.51	3.60	1.80	.0020	.0215	.0178	.0037	.36	.0009	.0000	.69	0.6	-

Silver Lake, Pembroke.

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 12 samples collected in 1903.	.09	2.96	1.10	.0016	.0138	.0113	.0025	.60	.0007	.0000	.25	0.4	-

Works are now being constructed to convey the water of Silver Lake to Brockton.

Water Supply of Brookline.

Faucet at Low-service Pumping Station.

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 10 samples collected in 1903.	.07	8.75	-	.0039	.0044	-	-	.56	.0280	.0003	.13	4.7	.0165
Average of nine previous years, .	.03	8.94	-	.0019	.0034	-	-	.58	.0343	.0001	.09	4.5	.0040

Water Supply of Cambridge. (See also page 17.)

Fresh Pond.

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 12 samples collected in 1903.	.21	7.31	2.45	.0059	.0217	.0154	.0063	.61	.0239	.0005	.37	3.3	-

Stony Brook Storage Reservoir, Waltham.

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 12 samples collected in 1903.	.46	5.58	2.23	.0030	.0221	.0185	.0036	.45	.0132	.0002	.61	2.2	-

Upper Basin on Hobbs Brook.

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 12 samples collected in 1903.	.65	5.46	2.38	.0039	.0295	.0245	.0050	.34	.0100	.0001	.79	2.0	-

Lower Basin on Hobbs Brook.

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 12 samples collected in 1903.	.13	4.72	1.65	.0033	.0241	.0195	.0046	.35	.0051	.0001	.38	2.1	-

CAMBRIDGE.

Water examined in Connection with Advice to the J. S. Bell Confectionery Company. (See also page 18.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
48311	**1903.** Nov. 30	Decided.	Cons.	-	158.60	.0340	.0034	52.00	.0020	.0002	.21	9.1	.3000

The sample was collected from a tubular well at the factory of the J. S. Bell Confectionery Company.

WATER SUPPLY OF CANTON.

Springdale Well.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 8 samples collected in 1903.	.00	3.51	-	.0001	.0006	-	-	.31	.0059	.0000	.01	1.0	.0067

Well near Henry's Spring.

Average of 8 samples collected in 1903.	.05	3.94	-	.0002	.0024	-	-	.35	.0225	.0000	.12	1.1	.0056

WATER SUPPLY OF CHELSEA.

(See *Metropolitan Water District*, pages 138-141.)

WATER SUPPLY OF CHESHIRE. — CHESHIRE WATER COMPANY.

Reservoir on Thunder Brook.

Average of 3 samples collected in 1903.	.01	3.90	.55	.0009	.0034	.0031	.0003	.05	.0067	.0000	.07	2.8	-

Reservoir on Kitchen Brook.

Average of 4 samples collected in 1903.	.01	4.18	.69	.0005	.0042	.0026	.0016	.05	.0052	.0000	.08	2.7	-

WATER SUPPLY OF CHICOPEE.

Morton Brook Reservoir.

Average of 2 samples collected in 1903.	.02	3.35	.65	.0010	.0071	.0061	.0010	.13	.0070	.0001	.08	0.8	-

CHICOPEE.

Cooley Brook Reservoir.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 2 samples collected in 1903.	.29	3.52	1.32	.0012	.0071	.0059	.0012	0.11	.0050	.0000	.30	0.7	-
Average of nine previous years, .	.74	4.28	1.54	.0016	.0151	.0119	.0032	0.12	.0041	.0000	.66	1.0	-

Water Supply of Cohasset. — Cohasset Water Company.

Tubular Wells west of the Main Village (Old System).

Average of 2 samples collected in 1903.	.01	12.70	-	.0009	.0018	-	-	1.62	.0240	.0000	.05	6.0	.0160
Average of ten previous years, .	.11	15.04	-	.0004	.0018	-	-	1.80	.0248	.0000	.04	6.9	.0384

Tubular Wells in Ellms Meadow.

Average of 6 samples collected in 1903.	.01	13.30	-	.0004	.0012	-	-	1.45	.1020	.0000	.03	5.7	.0065
Average of five previous years, .	.00	12.16	-	.0001	.0011	-	-	1.37	.0615	.0000	.01	4.7	.0041

Filter Gallery at Lily Pond.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1903.												
45197	May 4	V. slight.	None.	.07	12.50	.0006	.0114	1.23	.0050	.0005	.19	4.9	.0230
45605	June 1	Slight.	Slight.	.14	10.40	.0022	.0106	1.17	.0010	.0002	.21	4.3	.0070
45656	June 2	V. slight.	Cons.	.04	12.80	.0328	.0100	1.12	.0020	.0000	.25	6.4	.0270
46088	July 2	Slight.	V. slight.	.08	10.30	.0320	.0094	1.10	.0010	.0000	.28	4.3	.0010
46655	Aug. 6	V. slight	None.	.20	10.30	.0520	.0084	1.10	.0010	.0002	.37	4.7	.0050
46960	Aug. 27	V. slight.	None.	.19	10.20	.0600	.0110	1.10	.0020	.0001	.36	4.7	.0020
47134	Sept. 10	Slight.	None.	.20	10.10	.0574	.0134	1.07	.0020	.0001	.46	4.7	.0090
47518	Oct. 8	V. slight.	None.	.12	11.30	.0780	.0066	1.10	.0010	.0001	.33	4.4	.0060
47775	Oct. 26	V. slight.	None.	.10	10.50	.0072	.0108	1.16	.0050	.0002	.37	4.7	.0060
Av.*.	....	....	....	.12	10.94	.0343	.0105	1.13	.0023	.0001	.31	4.7	.0099

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

COLRAIN.

WATER SUPPLY OF COLRAIN. — GRISWOLDVILLE MANUFACTURING COMPANY. (See also page 18.)

McClellan Brook.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1903.														
44290	Feb. 23	None.	None.	.00	5.05	1.30	.0020	.0042	.0042	.0000	.10	.0050	.0000	.08	3.3
45558	May 25	None.	None.	.00	6.60	0.65	.0004	.0018	.0018	.0000	.08	.0020	.0000	.05	4.4
46955	Aug. 26	V. slight.	V. slight.	.10	7.25	1.60	.0000	.0088	.0072	.0014	.10	.0040	.0000	.22	3.0
47928	Nov. 2	None.	V. slight.	.02	6.30	0.75	.0006	.0038	.0038	.0000	.12	.0010	.0001	.09	4.2
48179	Nov. 20	V. slight.	None.	.03	6.00	1.15	.0008	-	-	-	.11	.0030	.0000	.12	3.4
48247	Nov. 24	None.	None.	.03	5.60	0.75	.0018	.0048	.0042	.0006	.10	.0030	.0000	.19	3.5
Av.*	....	....	....	.03	6.22	1.11	.0009	.0047	.0043	.0004	.10	.0033	.0000	.12	3.6

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Griswold Spring.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.			
	1903.														
47929	Nov. 2	None.	None.	.00	7.80	.0000	.0018	-	-	.08	.0100	.0000	.09	5.0	.0050
48180	Nov. 20	Slight.	Cons.	.00	7.45	.0008	.0056	.0028	.0028	.08	.0120	.0001	.02	5.0	.0030

WATER SUPPLY OF CONCORD AND LINCOLN. (See also page 41.)

Sandy Pond.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.			
Average of 4 samples collected in 1903.	.01	2.27	0.90	.0007	.0106	.0095	.0011	.25	.0022	.0000	.16	0.5	-

CONCORD AND LINCOLN.

Waters examined in Connection with Advice relative to a Proposed Water Supply for the Massachusetts Reformatory. (See also page 19.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1903.												
47092	Sept. 8	V. slight.	V. slight.	.02	3.00	.0000	.0006	.38	.0050	.0000	.06	0.6	.0230
47334	Sept. 25	Slight.	Slight.	.02	2.80	.0000	.0008	.38	.0050	.0000	.02	0.3	.0100
47093	Sept. 8	Decided.	Slight.	.08	6.90	.0000	.0008	.28	.0050	.0000	.06	1.0	.0610
47335	Sept. 25	V. slight.	V. slight.	.02	4.00	.0008	.0006	.30	.0050	.0000	.02	1.4	.0060
47094	Sept. 8	Decided.	None.	.09	7.20	.0008	.0004	.15	.0100	.0000	.05	2.3	.0400
47336	Sept. 25	Slight.	Slight.	.05	6.80	.0008	.0014	.18	.0050	.0000	.03	2.5	.0420

The samples were collected from tubular wells on an island in Warner's Pond.

Water examined in Connection with Advice relative to a Proposed Water Supply for the Middlesex School. (See also page 19.)

	1903.												
47872	Oct. 28	V. slight.	V. slight.	.00	5.80	.0010	.0022	.35	.0250	.0005	.05	2.0	.0030

The sample was collected from a collecting trench on the hillside back of the school building.

CONWAY.

Waters examined in Connection with Advice relative to a Proposed Water Supply. (See also page 20.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1903.														
44090	Feb. 3	None.	V. slight.	.01	4.75	1.20	.0000	.0032	.0028	.0004	.11	.0160	.0000	.11	2.5
44088	Feb. 3	None.	V. slight.	.01	4.00	0.80	.0002	.0030	.0030	.0000	.07	.0040	.0000	.09	2.0
44089	Feb. 3	None.	V. slight.	.11	3.50	1.00	.0006	.0058	.0048	.0010	.08	.0140	.0000	.21	1.4

The first sample was collected from Roaring Brook; the second, from a brook on the south side of South River discharging into that stream above the bridge at Burkville; the last, from Bradford Brook.

COTTAGE CITY.

Water Supply of Cottage City. — Cottage City Water Company.

Springs.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.02	3.80	-	.0005	.0008	-	-	0.96	.0092	.0000	.02	0.6	.0140

Water Supply of Dalton Fire District.

Upper Reservoir.

Average of 4 samples collected in 1903.	.17	2.65	1.00	.0014	.0085	.0063	.0022	0.07	.0180	.0000	.34	0.7	-

Water Supply of Danvers and Middleton.

Middleton Pond.

Average of 3 samples collected in 1903.	.63	3.60	1.90	.0019	.0202	.0172	.0030	0.30	.0010	.0001	.85	1.2	-

Water Supply of Dedham. — Dedham Water Company.

Large Well.

Average of 6 samples collected in 1903.	.00	8.25	-	.0010	.0033	-	-	0.67	.1185	.0000	.05	8.6	.0078

Tubular Well.

Average of 7 samples collected in 1903.	.00	15.76	-	.0016	.0019	-	-	1.46	.4500	.0002	.04	6.1	.0163

Water Supply of Deerfield. — South Deerfield Water Supply District.

Roaring Brook.

Average of 6 samples collected in 1903.	.04	5.76	0.88	.0007	.0039	.0034	.0005	0.09	.0080	.0000	.09	3.4	-

DRACUT.

Water Supply of Dracut. — American Woolen Company.

Tubular Wells.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 6 samples collected in 1903.	.00	4.80	-	.0007	.0015	-	-	.21	.0242	.0000	.04	1.7	.0035

Water Supply of East Bridgewater.

(See *Bridgewater.*)

Water examined in Connection with Advice to the Town Authorities. (See also page 22.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
45567	1903. May 27	Slight.	Cons.	.22	9.50	.0100	.0076	.69	.0290	.0002	.13	3.1	.1000

The sample was collected from a well at the town farm.

Water Supply of Easthampton.

Bassett Brook.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 5 samples collected in 1903.	.17	3.32	.97	.0013	.0066	.0056	.0010	.12	.0064	.0001	.24	1.1	-

Water Supply of Easton. — North Easton Village District.

Well.

Average of 6 samples collected in 1903.	.01	4.42	-	.0003	.0019	-	-	.46	.0538	.0000	.02	1.5	.0055

Water Supply of Everett.

(See *Metropolitan Water District*, pages 138–141.)

Water Supply of Fairhaven. — Fairhaven Water Company.

Tubular Wells.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 7 samples collected in 1903.	.48	6.34	-	.0014	.0105	-	-	1.00	.0232	.0000	.60	2.0	.0220

Water Supply of Fall River. (See also page 22.)

North Watuppa Lake.

Average of 12 samples collected in 1903.	.16	3.40	1.41	.0013	.0170	.0145	.0025	0.52	.0020	.0001	.38	0.7	-

Water Supply of Falmouth.

Tubular Wells.

Average of 6 samples collected in 1903.	.04	2.95	-	.0008	.0094	-	-	0.94	.0008	.0000	.07	0.2	.0138

Long Pond.

Average of 6 samples collected in 1903.	.01	3.01	1.08	.0011	.0102	.0089	.0013	0.93	.0003	.0000	.07	0.3	-

Water Supply of Fitchburg. (See also page 26.)

Scott Reservoir.

Average of 4 samples collected in 1903.	.15	2.45	1.02	.0017	.0167	.0125	.0042	0.15	.0017	.0001	.38	0.3	-

Meetinghouse Pond, Westminster.

Average of 4 samples collected in 1903.	.08	2.17	0.76	.0021	.0134	.0119	.0015	0.14	.0017	.0000	.28	0.5	-

Water Supply of Foxborough Water Supply District.

Tubular Wells.

Average of 8 samples collected in 1903.	.01	3.85	-	.0007	.0005	-	-	0.33	.0452	.0000	.01	0.8	.0095

FRAMINGHAM.

Water Supply of Framingham. — Framingham Water Company.

Filter Gallery.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 9 samples collected in 1903.	.02	8.44	-	.0035	.0041	-	-	.85	.0399	.0004	.07	4.1	.0112

Water Supply of Franklin. — Franklin Water Company.

Wells.

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 5 samples collected in 1903.	.39	6.17	2.55	.0056	.0204	.0170	.0034	.62	.0692	.0002	.53	2.0	-
Average of nine previous years, .	.27	7.53	-	.0006	.0084	-	-	.74	.1626	.0001	.31	2.8	.0137

Water Supply of Gardner.

Crystal Lake.

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 3 samples collected in 1903.	.05	3.90	1.30	.0011	.0171	.0135	.0036	.31	.0053	.0000	.23	1.6	-

Water examined in Connection with Advice to the Central Oil and Gas Stove Company. (See also page 26.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1903.														
43676	Jan. 5	V. slight.	V. slight.	.07	5.15	1.50	.0040	.0170	.0140	.0030	.55	.0600	.0000	.23	2.1

The sample was collected from a brook used as a source of water supply by the Central Oil and Gas Stove Company.

Water Supply of Gloucester.

Dike's Brook Storage Reservoir.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.			
Average of 4 samples collected in 1903.	.35	3.67	1.66	.0034	.0168	.0140	.0028	0.82	.0035	.0000	.43	0.4	-

Wallace Pond.

	Color.	Residue Total.	Loss on Ignition.	Ammonia Free.	Alb. Total.	Alb. Dissolved.	Alb. Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.35	3.96	1.57	.0023	.0193	.0148	.0045	0.97	.0012	.0000	.43	0.4	-

Haskell Reservoir, Surface.

	Color.	Residue Total.	Loss on Ignition.	Ammonia Free.	Alb. Total.	Alb. Dissolved.	Alb. Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 12 samples collected in 1903.	.44	3.94	1.71	.0028	.0208	.0148	.0060	0.81	.0012	.0000	.55	0.4	-

Haskell Reservoir, Bottom.

	Color.	Residue Total.	Loss on Ignition.	Ammonia Free.	Alb. Total.	Alb. Dissolved.	Alb. Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 11 samples collected in 1903.	.53	4.15	1.67	.0050	.0199	.0156	.0043	0.80	.0015	.0000	.57	0.6	-

Water Supply of Grafton. — Grafton Water Company.

Filter Gallery.

	Color.	Residue Total.	Loss on Ignition.	Ammonia Free.	Alb. Total.	Alb. Dissolved.	Alb. Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 3 samples collected in 1903.	.10	11.07	-	.0005	.0042	-	-	1.19	.2333	.0000	.15	3.9	.0113

Water Supply of Great Barrington Fire District.

East Mountain Reservoir.

	Color.	Residue Total.	Loss on Ignition.	Ammonia Free.	Alb. Total.	Alb. Dissolved.	Alb. Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 3 samples collected in 1903.	.14	4.45	1.63	.0047	.0068	.0055	.0013	0.10	.0013	.0004	.29	3.0	-

Green River.

	Color.	Residue Total.	Loss on Ignition.	Ammonia Free.	Alb. Total.	Alb. Dissolved.	Alb. Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 6 samples collected in 1903.	.02	8.51	1.53	.0011	.0027	.0026	.0001	0.08	.0273	.0000	.06	7.2	-

GREAT BARRINGTON FIRE DISTRICT.

Waters examined in Connection with Advice relative to Additional Water Supply.

(See also pages 27, 29.)

Goodale Brook.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1902.														
39362	Mar. 18	None.	Slight.	.02	1.60	0.60	.0000	.0018	.0012	.0006	.05	.0060	.0000	.08	0.8
39890	May 1	V. slight.	V. slight.	.02	2.75	0.75	.0000	.0052	.0044	.0008	.06	.0220	.0000	.09	1.6
40278	May 29	None.	V. slight.	.01	3.50	1.00	.0010	.0032	.0024	.0008	.06	.0130	.0000	.04	2.2
40821	June 24	None.	V. slight.	.00	3.70	0.60	.0008	.0034	.0022	.0012	.08	.0110	.0000	.08	2.6
41220	July 17	None.	V. slight.	.00	4.00	0.75	.0008	.0026	.0022	.0004	.07	.0100	.0000	.35	2.6
41694	Aug. 17	None.	V. slight.	.01	3.65	0.75	.0014	.0024	.0020	.0004	.07	.0090	.0000	.04	2.5
42314	Sept. 16	None.	V. slight.	.00	4.75	1.15	.0002	.0018	.0018	.0000	.06	.0100	.0000	.13	3.3

Harmon Brook.

	1902.														
41219	July 17	None.	V. slight.	.18	5.75	1.25	.0016	.0092	.0088	.0004	.07	.0120	.0001	.11	4.9
42316	Sept. 17	None.	V. slight.	.22	8.65	1.75	.0012	.0102	.0094	.0008	.08	.0050	.0000	.37	4.7

Kilbourne Brook.

	1903.														
45260	May 10	V. slight.	Slight.	.02	9.05	1.80	.0006	.0050	.0028	.0022	.11	.0300	.0003	.04	7.4
45428	May 18	None.	Slight.	.00	10.35	1.80	.0008	.0028	.0024	.0004	.08	.0470	.0000	.08	7.8

Mangion Brook.

45262	May 10	V. slight.	Slight.	.60	4.35	2.00	.0028	.0186	.0156	.0030	.08	.0030	.0003	.64	2.0
45430	May 18	None.	V. slight.	.54	5.15	2.25	.0024	.0162	.0148	.0014	.07	.0090	.0000	.58	2.6

Snyder Brook.

45261	May 10	V. slight.	Slight.	.03	10.50	2.45	.0006	.0054	.0048	.0006	.09	.0030	.0003	.10	8.9
45431	May 18	None.	V. slight.	.02	11.45	3.00	.0018	.0048	.0046	.0002	.08	.0030	.0000	.16	9.4

Soda Creek.

45429	May 18	V. slight.	V. slight.	.12	5.90	1.15	.0018	.0100	.0076	.0024	.07	.0030	.0000	.28	3.9

GREAT BARRINGTON FIRE DISTRICT.

Fenton Brook.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1903.														
45427	May 12	None.	Slight.	.00	7.10	0.80	.0026	.0032	.0030	.0002	.06	.0000	.0000	.08	4.9

Test Wells near Green River.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1903.												
45432	May 18	None.	Slight.	.00	11.00	.0010	.0028	.08	.0310	.0000	.07	7.5	.0100
46209	July 6	V. slight.	Cons.	.00	17.10	.0000	.0008	.09	.0210	.0000	.05	14.8	.0010
46210	July 8	Decided.	Cons.	.06	11.90	.0002	.0048	.12	.0120	.0003	.13	8.6	.0140

Water Supply of Greenfield Fire District.

Glen Reservoir, Leyden.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.			
Average of 4 samples collected in 1903.	.02	5.08	1.19	.0009	.0038	.0037	.0001	.10	.0135	.0000	.08	3.0	-

Water Supply of Groton. — Groton Water Company.

Well.

Average of 9 samples collected in 1903.	.00	4.29	-	.0008	.0007	-	-	.15	.0062	.0000	.02	1.9	.0076

HATFIELD.

Water Supply of Hatfield.

Reservoir.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.04	4.05	1.00	.0008	.0030	.0028	.0002	.12	.0195	.0000	.10	1.9	-

Water Supply of Haverhill.

Crystal Lake.

Average of 4 samples collected in 1903.	.15	3.06	1.26	.0014	.0152	.0133	.0019	.27	.0022	.0000	.34	0.9	-

Kenoza Lake.

Average of 4 samples collected in 1903.	.08	3.86	1.31	.0013	.0139	.0119	.0020	.38	.0017	.0000	.25	1.7	-

Lake Saltonstall.

Average of 4 samples collected in 1903.	.08	6.59	1.69	.0025	.0134	.0113	.0021	.68	.0020	.0000	.17	2.9	-

Lake Pentucket.

Average of 4 samples collected in 1903.	.05	3.66	1.32	.0011	.0146	.0134	.0012	.38	.0017	.0000	.23	1.6	-

Johnson's Pond, in Boxford and Groveland.

Average of 4 samples collected in 1903.	.11	3.99	1.33	.0018	.0151	.0141	.0010	.35	.0022	.0000	.34	1.8	-

Millvale Reservoir, on East Meadow River.

Average of 4 samples collected in 1903.	.63	4.82	2.11	.0015	.0180	.0163	.0017	.34	.0030	.0000	.77	1.6	-

Water Supply of Hingham. — Hingham Water Company. (See also page 30.)

Accord Pond.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 8 samples collected in 1903.	0.19	2.92	1.22	.0013	.0117	.0105	.0012	.55	.0019	.0000	0.37	0.3	-

Well and Filter Gallery near Fulling Mill Pond.

	Color.	Residue: Total.	Residue: Loss on Ignition.	Ammonia: Free.	Albuminoid: Total.	Albuminoid: Dissolved.	Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 6 samples collected in 1903.	0.10	4.92	1.43	.0014	.0049	.0041	.0008	.66	.0155	.0001	0.16	1.3	-
Average of ten previous years, .	0.18	4.83	1.26	.0021	.0102	.0067	.0035	.72	.0137	.0000	0.21	1.3	-

Accord Brook.

	Color.	Residue: Total.	Residue: Loss on Ignition.	Ammonia: Free.	Albuminoid: Total.	Albuminoid: Dissolved.	Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 6 samples collected in 1903.	1.36	5.81	2.84	.0024	.0208	.0183	.0025	.66	.0053	.0000	1.31	1.0	-

Water Supply of Holbrook.

(See *Randolph*)

Water Supply of Holliston. — Holliston Water Company.

Well and Pond.

	Color.	Residue: Total.	Residue: Loss on Ignition.	Ammonia: Free.	Albuminoid: Total.	Albuminoid: Dissolved.	Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 7 samples collected in 1903.	0.26	3.75	-	.0010	.0108	-	-	.29	.0043	.0000	0.35	1.3	.0323

Water Supply of Holyoke. (See also page 33.)

Whiting Street Storage Reservoir.

	Color.	Residue: Total.	Residue: Loss on Ignition.	Ammonia: Free.	Albuminoid: Total.	Albuminoid: Dissolved.	Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	0.07	3.87	1.42	.0017	.0179	.0143	.0036	.14	.0022	.0000	0.28	2.3	-
Average of twelve previous years,	0.20	4.94	1.57	.0041	.0272	.0194	.0078	.18	.0063	.0001	0.30	2.6	-

Fomar Reservoir on Manhan River in Southampton.

	Color.	Residue: Total.	Residue: Loss on Ignition.	Ammonia: Free.	Albuminoid: Total.	Albuminoid: Dissolved.	Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	0.30	3.74	1.44	.0012	.0127	.0108	.0019	.14	.0020	.0000	0.40	1.5	-

HOLYOKE.

Wright and Ashley Ponds.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.10	4.32	1.62	.0019	.0141	.0107	.0034	.13	.0025	.0001	.26	2.1	-

Water examined in Connection with Advice to the City Authorities. (See also page 33.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
44533	**1903.** Mar. 11	V. slight.	V. slight.	.00	21.80	.0004	.0008	.41	.4400	.0000	.02	8.9	.0060

The sample was collected from a tubular well supplying the factory of the National Blank Book Company.

Water Supply of Hopedale.

(See *Milford*)

Water Supply of Hopkinton.

Tubular Wells.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 7 samples collected in 1903.	.01	11.66	-	.0003	.0019	-	-	1.00	.4000	.0000	.04	4.5	.0065

Water Supply of Hudson.

Gates Pond, Berlin.

Average of 4 samples collected in 1903.	.06	2.40	.96	.0036	.0135	.0123	.0012	0.20	.0050	.0001	.17	0.6	-

Water Supply of Hull.

(See *Hingham*.)

HULL.

Water examined in Connection with Advice relative to the Water Supply of Fort Revere. (See also page 34.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1903.												
44002	Jan. 29	Slight.	Heavy.	–	31.80	.0122	.0010	2.45	.0000	.0002	.05	8.0	.1200
44269	Feb. 20	Decided.	Cons.	.06	27.20	.0148	.0016	2.54	.0010	.0004	.09	15.1	.0570
44534	Mar. 11	V. slight.	V. slight.	.05	25.00	.0136	.0020	2.54	.0020	.0007	.03	15.4	.0510

The samples were collected from faucets supplied from a tubular well.

Water Supply of Hyde Park. — Hyde Park Water Company.

Tubular Wells near the Neponset River.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 14 samples collected in 1903.	.06	10.04	–	.0068	.0040	–	–	1.06	.0977	.0003	.11	4.3	.0393
Average of ten previous years, .	.04	9.96	–	.0093	.0041	–	–	1.26	.1015	.0002	.09	4.1	.0170

Tubular Wells near Mother Brook.

Average of 14 samples collected in 1903.	.08	7.57	–	.0008	.0062	–	–	0.81	.1696	.0000	.19	2.7	.0072
Average of two previous years, .	.03	8.53	–	.0008	.0044	–	–	0.88	.2294	.0001	.08	3.2	.0067

Waters examined in Connection with Advice to the B. F. Sturtevant Company. (See also page 34.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1903.												
47095	Sept. 8	Decided.	Cons.	.08	31.80	.0002	.0018	0.95	.0250	.0009	.11	6.0	.1340
47250	Sept. 17	Decided.	Cons.	.02	15.80	.0008	.0100	1.30	.3400	.0004	.16	5.4	.0480
47187	Sept. 15	Decided.	Cons.	.08	20.50	.0304	.0028	1.58	.4800	.0016	.02	0.8	.0170

The first sample was collected from a tubular well 500 feet deep; the second, from a tubular well 25 feet deep; the last, from an excavation in Readville Street.

IPSWICH.

Water Supply of Ipswich.

Dow's Brook, at Entrance to Storage Reservoir.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 11 samples collected in 1903.	.31	4.58	1.61	.0015	.0105	.0093	.0012	.49	.0044	.0001	.42	1.6	-

Dow's Brook Storage Reservoir.

Average of 13 samples collected in 1903.	.27	4.23	1.57	.0022	.0195	.0165	.0030	.55	.0023	.0001	.43	1.5	-

Bull Brook.

Average of 11 samples collected in 1903.	.98	6.06	2.64	.0030	.0212	.0190	.0022	.66	.0060	.0000	.97	2.0	-

Water Supply of Kingston.

Tubular Wells.

Average of 7 samples collected in 1903.	.00	4.12	-	.0006	.0018	-	-	.73	.0066	.0000	.01	0.8	.0059

Water Supply of Lawrence. (See also pages 35, 38.)

Merrimack River above Lawrence.

Average of 12 samples collected in 1903.	.33	4.21	1.60	.0088	.0224	.0168	.0056	.27	.0064	.0004	.58	1.2	-
Average of twelve previous years,	.40	3.98	1.53	.0065	.0210	.0166	.0044	.22	.0074	.0002	.53	1.2	-

Merrimack River after Filtration.

Average of 12 samples collected in 1903.	.31	4.79	1.62	.0127	.0081	.0074	.0007	.30	.0326	.0001	.36	1.8	.0735
Average of nine previous years, .	.40	4.97	1.56	.0115	.0099	.0088	.0011	.27	.0273	.0002	.36	2.0	-

Distributing Reservoir.

Average of 12 samples collected in 1903.	.26	4.40	1.55	.0052	.0087	.0078	.0009	.28	.0246	.0002	.33	1.6	.0445
Average of nine previous years, .	.28	4.47	1.49	.0044	.0106	.0092	.0014	.26	.0233	.0001	.34	1.7	-

LAWRENCE.

Water examined in Connection with Advice to the Everett Mills. (See also page 40.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1903.												
47246	Sept. 17	None.	None.	.00	30.20	.0000	.0016	3.28	1.0600	.0002	.04	10.0	.0070
L. 35298	Oct. 14	None.	None.	.00	30.30	.0000	.0008	3.20	1.1800	.0000	.00	5.5	-
L. 35369	Oct. 28	None.	None.	.00	29.80	.0000	.0008	2.97	1.0800	-	.01	5.5	-

The samples were collected from a well at the Everett mills.

Water Supply of Lee. — Berkshire Water Company.

Lower Reservoir.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.			
Average of 4 samples collected in 1903.	.13	4.01	1.22	.0008	.0084	.0077	.0007	.07	.0040	.0000	.28	1.7	-

Water Supply of Leicester Water Supply District.

Well in Paxton.

Average of 15 samples collected in 1903.	.30	8.35	-	.0093	.0115	-	-	.19	.0411	.0002	.40	3.8	.0259

Faucet.

Average of 12 samples collected in 1903.	.09	5.68	-	.0005	.0040	-	-	.21	.1057	.0000	.16	2.3	.0125

Water Supply of Lenox. — Lenox Water Company.

Storage Reservoir.

Average of 2 samples collected in 1903.	.04	7.07	1.67	.0006	.0070	.0055	.0015	.09	.0120	.0000	.10	4.5	-
Average of five previous years, .	.06	7.90	1.27	.0017	.0127	.0106	.0021	.09	.0042	.0000	.17	5.8	-

LEOMINSTER.

Water Supply of Leominster.

Haynes Reservoir.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.			
Average of 4 samples collected in 1903.	.17	2.29	1.14	.0016	.0259	.0200	.0059	.14	.0007	.0001	.41	0.1	-

Morse Reservoir.

Average of 4 samples collected in 1903.	.14	2.17	1.01	.0018	.0160	.0135	.0025	.14	.0013	.0001	.34	0.1	-

Fall Brook, above Fall Brook Reservoir.

Average of 13 samples collected in 1903.	.34	2.78	1.24	.0012	.0126	.0112	.0014	.17	.0019	.0001	.50	0.2	-

Fall Brook Reservoir.

Average of 13 samples collected in 1903.	.13	2.25	0.95	.0015	.0140	.0114	.0026	.14	.0017	.0000	.32	0.3	-

Water Supply of Lexington.

(See *Metropolitan Water District*, pages 138-141.)

Water Supply of Lincoln. (See also page 41.)

(See *Concord.*)

Littleton.

Water examined in Connection with Advice relative to a Proposed Water Supply.

(See also page 41.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
44106	1903. Feb. 6	None.	V. slight.	.82	3.90	2.30	.0020	.0172	.0160	.0012	.22	.0030	.0001	.91	1.7

The sample was collected from the outlet of Long Pond.

Water Supply of Longmeadow.

Cooley Brook.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.06	4.32	1.10	.0013	.0061	.0038	.0023	.17	.0247	.0002	.14	2.2	-

Water Supply of Lowell. (See also page 42.)

Merrimack River, above Lowell.

Average of 14 samples collected in 1903.	.29	3.65	1.42	.0045	.0159	.0123	.0036	.20	.0050	.0002	.54	1.0	-
Average of twelve previous years,	.36	3.59	1.39	.0036	.0167	.0136	.0031	.17	.0071	.0001	.50	1.1	-

Tubular Wells in the Valley of the Merrimack River, near the Pawtucket Boulevard.

Average of 15 samples collected in 1903.	.03	4.09	-	.0037	.0027	-	-	.23	.0230	.0002	.07	1.5	.0317
Average of seven previous years,	.08	4.35	-	.0074	.0032	-	-	.26	.0231	.0001	.07	1.7	.0309

Pumping Station No. 1.

Average of 12 samples collected in 1903.	.02	4.23	-	.0021	.0026	-	-	.25	.0310	.0001	.07	1.6	.0189
Average of four previous years, .	.06	4.45	-	.0048	.0035	-	-	.27	.0291	.0001	.08	1.7	.0246

The samples represent water from the Boulevard wells.

Waters examined in Connection with Advice to the Lowell Textile School. (See also page 42.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1903.												
47274	Sept. 21	None.	None.	.01	14.90	.0000	.0022	.97	.8500	.0004	.07	6.9	.0080
47275	Sept. 21	None.	Cons.	.06	18.30	.0000	.0092	.88	.7000	.0000	.26	6.4	.0190

The samples were collected from springs at the Lowell Textile School.

LUDLOW.

WATER SUPPLY OF LUDLOW.

(See *Springfield.*)

WATER SUPPLY OF LYNN AND SAUGUS. (See also page 43.)

Breed's Pond.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid Total.	Albuminoid Dissolved.	Albuminoid Suspended.		Nitrates.	Nitrites.			
Average of 12 samples collected in 1903.	.33	3.44	1.55	.0029	.0188	.0157	.0031	.45	.0022	.0000	0.51	0.8	-
Average of twelve previous years,	.43	3.60	1.44	.0027	.0208	.0176	.0032	.50	.0037	.0000	0.50	0.9	-

Birch Pond.

Average of 12 samples collected in 1903.	.34	3.57	1.63	.0024	.0214	.0170	.0044	.42	.0041	.0000	0.49	0.9	-
Average of twelve previous years,	.46	4.10	1.65	.0036	.0264	.0213	.0051	.52	.0056	.0001	0.51	1.1	-

Walden Pond.

Average of 5 samples collected in 1903.	.37	3.58	1.67	.0032	.0228	.0178	.0050	.38	.0014	.0000	0.54	0.8	-
Average of twelve previous years,	.72	3.88	1.89	.0051	.0385	.0277	.0108	.40	.0042	.0000	0.69	0.6	-

Glen Lewis Pond.

Average of 8 samples collected in 1903.	.26	3.01	1.38	.0059	.0202	.0157	.0045	.35	.0016	.0001	0.40	0.3	-
Average of eleven previous years,	.45	3.61	1.76	.0100	.0449	.0276	.0173	.40	.0051	.0001	0.51	0.5	-

Hawkes Pond.

Average of 12 samples collected in 1903.	.39	4.21	2.05	.0026	.0223	.0196	.0027	.46	.0025	.0000	0.62	1.3	-
Average of six previous years, .	.40	4.38	1.83	.0031	.0252	.0212	.0040	.46	.0050	.0001	0.58	1.4	-

Saugus River at Montrose.

Average of 12 samples collected in 1903.	.97	7.42	3.46	.0039	.0325	.0290	.0035	.71	.0040	.0001	1.13	3.1	-
Average of five previous years, .	.80	7.48	3.13	.0046	.0334	.0294	.0040	.65	.0057	.0002	0.93	3.1	-

WATER SUPPLY OF MALDEN.

(See *Metropolitan Water District*, pages 138-141.)

Water Supply of Manchester.

Large Well.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 8 samples collected in 1903.	.00	11.59	-	.0002	.0006	-	-	1.88	.1629	.0000	.02	4.0	.0081

Tubular Wells near Coolidge Spring.

Average of 4 samples collected in 1903.	.00	8.88	-	.0006	.0011	-	-	1.24	.1808	.0000	.03	2.7	.0020

Water Supply of Mansfield Water Supply District.

Well.

Average of 8 samples collected in 1903.	.00	2.64	-	.0001	.0007	-	-	0.25	.0015	.0000	.01	0.5	.0029

Water Supply of Marblehead.

Collecting Well No. 1.

Average of 8 samples collected in 1903.	.06	16.65	-	.0142	.0023	-	-	2.25	.0189	.0002	.06	7.0	.1873
Average of twelve previous years,	.07	17.44	-	.0069	.0022	-	-	2.89	.0578	.0002	.05	7.4	.1079

Collecting Well No. 2.

Average of 8 samples collected in 1903.	.05	17.00	-	.0254	.0028	-	-	1.60	.0019	.0001	.09	7.0	.2911
Average of five previous years, .	.08	16.25	-	.0242	.0035	-	-	1.64	.0049	.0000	.09	6.3	.3482

Marion.

Water examined in Connection with Advice to the New York, New Haven & Hartford Railroad Company. (See also page 45.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1903.												
45255	May 8	V. slight.	V. slight.	.03	36.80	.0960	.0128	4.70	2.0000	.0002	.23	8.6	.0080

The sample was collected from a well at the Marion railroad station.

MARLBOROUGH.

WATER SUPPLY OF MARLBOROUGH. (See also page 45.)

Lake Williams.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	0.07	3.98	1.49	.0027	.0210	.0164	.0046	0.47	.0042	.0001	0.24	1.5	-

North Branch of Millham Brook, near its Entrance to the Millham Brook Storage Reservoir.

	Color.	Residue Total.	Loss on Ignition.	Ammonia Free.	Alb. Total.	Alb. Dissolved.	Alb. Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 12 samples collected in 1903.	1.05	5.45	2.33	.0028	.0214	.0183	.0031	0.41	.0095	.0001	1.02	1.4	-

Millham Brook, near its Entrance to the Millham Brook Storage Reservoir.

	Color.	Residue Total.	Loss on Ignition.	Ammonia Free.	Alb. Total.	Alb. Dissolved.	Alb. Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 11 samples collected in 1903.	0.48	5.38	2.08	.0026	.0178	.0159	.0019	0.43	.0165	.0001	0.57	2.0	-

Millham Brook Storage Reservoir, at Surface.

	Color.	Residue Total.	Loss on Ignition.	Ammonia Free.	Alb. Total.	Alb. Dissolved.	Alb. Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 12 samples collected in 1903.	0.47	3.85	1.60	.0043	.0190	.0158	.0032	0.31	.0065	.0001	0.51	1.4	-
Average of seven previous years,	0.57	4.06	1.70	.0052	.0289	.0223	.0066	0.29	.0083	.0001	0.57	1.3	-

Millham Brook Storage Reservoir, at Bottom.

	Color.	Residue Total.	Loss on Ignition.	Ammonia Free.	Alb. Total.	Alb. Dissolved.	Alb. Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 11 samples collected in 1903.	0.79	4.44	1.89	.0197	.0222	.0181	.0041	0.30	.0061	.0001	0.60	1.5	-
Average of seven previous years,	1.01	4.77	1.95	.0341	.0332	.0246	.0086	0.30	.0079	.0002	0.67	1.4	-

WATER SUPPLY OF MARSHFIELD. — BRANT ROCK WATER COMPANY.

Well.

	Color.	Residue Total.	Loss on Ignition.	Ammonia Free.	Alb. Total.	Alb. Dissolved.	Alb. Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
August, 1903, ...	0.00	10.60	-	.0002	.0008	-	-	3.34	.0570	.0000	0.03	2.5	.0030

WATER SUPPLY OF MAYNARD.

White Pond.

	Color.	Residue Total.	Loss on Ignition.	Ammonia Free.	Alb. Total.	Alb. Dissolved.	Alb. Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	0.06	2.21	0.79	.0016	.0106	.0096	.0010	0.31	.0042	.0000	0.14	0.4	-

MEDFIELD.

Water Supply of Medfield. — Medfield Water Company.

Spring.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron
September, 1903,	.02	4.20	–	.0000	.0042	–	–	.26	.0030	.0000	.12	0.8	.0030

Waters examined in Connection with Advice relative to a Proposed Water Supply.
(See also page 46.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1902.												
43408	Dec. 3	Slight.	V. slight.	.00	5.30	.0004	.0004	.28	.0230	.0000	.01	1.1	.0080
43409	Dec. 3	Slight.	Slight.	.01	6.30	.0000	.0008	.29	.0210	.0000	.01	0.8	.0300
43430	Dec. 4	None.	V. slight.	.01	4.70	.0000	.0010	.33	.0150	.0000	.02	0.8	.0050
43473	Dec. 11	None.	V. slight.	.00	4.50	.0034	.0048	.32	.0090	.0000	.02	1.3	.0050

The first three samples were collected from test wells near Mill Brook; the last, from a spring in the vicinity of the test wells.

Water Supply of Medfield Insane Asylum.

Farm Pond, Sherborn.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.01	1.76	.60	.0006	.0097	.0087	.0010	.22	.0015	.0000	.12	0.2	-

Water Supply of Medford.

(See *Metropolitan Water District,* pages 138–141.)

MELROSE.

WATER SUPPLY OF MELROSE.

(See *Metropolitan Water District*, pages 138–141.)

MERRIMAC.

Waters examined in Connection with Advice relative to a Proposed Water Supply.

(See also pages 48, 49.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1903.												
48171	Nov. 20	None.	None.	.00	4.60	.0006	.0012	.46	.0600	.0000	.00	2.2	.0080
48170	Nov. 20	None.	None.	.00	5.20	.0004	.0014	.46	.0600	.0000	.00	2.0	.0130
48186	Nov. 21	None.	None.	.00	5.60	.0010	.0008	.45	.0700	.0000	.00	2.3	.0050
48187	Nov. 21	None.	None.	.00	4.60	.0008	.0016	.43	.0720	.0000	.00	2.2	.0030
48200	Nov. 22	None.	None.	.00	4.90	.0004	.0010	.43	.0600	.0000	.02	2.1	.0070
48201	Nov. 22	None.	None.	.00	4.40	.0006	.0012	.44	.0600	.0000	.02	2.1	.0050
48202	Nov. 23	None.	None.	.00	4.30	.0006	.0008	.44	.0560	.0000	.02	2.1	.0030
48258	Nov. 24	None.	None.	.00	4.70	.0016	.0018	.44	.0600	.0000	.00	2.2	.0030
48259	Nov. 25	None.	None.	.00	4.70	.0010	.0006	.44	.0600	.0000	.00	2.0	.0030
48272	Nov. 26	None.	None.	.00	4.10	.0012	.0020	.45	.0560	.0000	.01	2.2	.0080
48273	Nov. 27	None.	None.	.00	4.20	.0012	.0016	.45	.0600	.0000	.01	2.3	.0050
48294	Nov. 28	None.	None.	.00	5.50	.0000	.0006	.45	.0580	.0000	.01	2.1	.0050
48295	Nov. 29	None.	None.	.00	4.90	.0000	.0004	.45	.0600	.0000	.00	2.1	.0030
48318	Nov. 30	None.	None.	.00	4.40	.0006	.0016	.45	.0560	.0000	.00	2.0	.0030
48317	Dec. 1	None.	None.	.00	4.90	.0006	.0020	.45	.0560	.0000	.01	2.0	.0050
48341	Dec. 2	None.	None.	.00	4.60	.0012	.0008	.48	.0560	.0000	.03	1.8	.0080
48342	Dec. 3	None.	None.	.00	4.40	.0010	.0008	.48	.0560	.0000	.02	1.8	.0050

The samples were collected while pumping continuously from a group of sixteen tubular wells at a rate of 300,000 gallons per day.

WATER SUPPLY OF METHUEN.

Tubular Wells.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 11 samples collected in 1903.	.10	7.96	-	.0006	.0042	-	-	.32	.0120	.0001	.12	3.7	.0322
Average of nine previous years, .	.07	7.33	-	.0003	.0039	-	-	.30	.0138	.0001	.09	3.1	.0098

MIDDLEBOROUGH FIRE DISTRICT.

Water Supply of Middleborough Fire District.

Well.

Averages by Years.

[Parts per 100,000.]

Year.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
1888,	.00	8.67	-	.0001	.0025	-	-	.96	.1494	.0001	-	-	-
1895,	.06	6.74	-	.0001	.0028	-	-	.74	.0687	.0000	.08	2.6	.0187
1896,	.18	6.54	-	.0003	.0038	-	-	.72	.0565	.0000	.09	2.4	.0288
1897,	.09	6.28	-	.0006	.0039	-	-	.71	.0580	.0000	.11	2.5	.0227
1898,	.16	6.78	-	.0008	.0044	-	-	.75	.0687	.0001	.14	2.7	.0408
1899,	.15	6.54	-	.0010	.0037	-	-	.69	.0684	.0000	.12	2.3	.0329
1900,	.15	5.99	-	.0012	.0037	-	-	.69	.0592	.0000	.10	2.2	.0489
1901,	.19	6.47	-	.0014	.0053	-	-	.67	.0762	.0000	.12	2.3	.0487
1902,	.22	6.26	-	.0026	.0054	-	-	.62	.0490	.0001	.16	2.1	.0841
1903,	.16	6.21	-	.0029	.0048	-	-	.63	.0504	.0001	.16	2.3	.0922

Water examined in Connection with Advice to the Town Authorities. **(See also page 50.)**

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1902.												
43169	Nov. 14	None.	Slight.	.00	23.00	.0018	.0034	2.10	0.8000	.0002	.09	6.6	.0160
43295	Nov. 24	None.	Slight.	.00	22.80	.0018	.0024	2.29	1.2200	.0000	.04	7.1	.0140
	1903.												
43684	Jan. 6	None.	None.	.00	23.70	.0010	.0016	2.26	1.2000	.0000	.01	8.4	.0050
44326	Feb. 25	None.	None.	.00	22.40	.0014	.0026	2.18	1.2000	.0001	.00	7.1	.0190

The samples were collected from a well in the shoe shop of Leonard & Barrows.

Water Supply of Middleton.

(See *Danvers*.)

MILFORD AND HOPEDALE.

WATER SUPPLY OF MILFORD AND HOPEDALE. — MILFORD WATER COMPANY.

Charles River, above Milford.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1903.														
43915	Jan. 24	V. slight.	V. slight.	.46	3.45	1.40	.0010	.0112	.0094	.0018	.24	.0000	.0000	0.59	1.0
44129	Feb. 9	None.	V. slight.	.36	2.80	1.35	.0010	.0104	.0096	.0008	.22	.0050	.0000	0.47	0.8
44229	Feb. 16	V. slight.	V. slight.	.43	3.15	1.25	.0010	.0090	.0078	.0012	.21	.0050	.0000	0.47	0.3
44293	Feb. 23	None.	None.	.37	3.10	1.30	.0008	.0124	.0108	.0016	.24	.0100	.0000	0.43	0.8
44618	Mar. 17	Slight.	Cons.	.38	2.75	1.15	.0012	.0134	.0120	.0014	.23	.0030	.0000	0.52	0.8
44983	Apr. 15	V. slight.	V. slight.	.36	2.85	1.30	.0018	.0178	.0132	.0046	.24	.0050	.0000	0.49	0.6
45339	May 15	Slight.	Cons.	.42	3.60	1.65	.0086	.0274	.0184	.0090	.35	.0110	.0002	0.58	0.6
45834	June 16	Decided.	Cons.	.90	4.55	2.45	.0032	.0260	.0212	.0048	.21	.0010	.0001	1.08	0.8
45895	June 19	Decided.	Cons.	.78	3.95	2.10	.0018	.0184	.0165	.0016	.20	.0040	.0001	0.98	0.5
46234	July 13	Slight.	Slight.	.65	3.95	1.90	.0008	.0172	.0124	.0048	.25	.0080	.0002	0.63	0.8
46701	Aug. 11	Slight.	Slight.	.60	4.00	1.75	.0008	–	–	–	.26	.0070	.0001	0.72	0.5
47118	Sept. 9	Slight.	Cons.	.33	4.00	2.25	.0020	.0258	.0238	.0020	.27	.0060	.0001	0.54	0.6
47167	Sept. 14	V. slight.	V. slight.	.34	2.85	1.10	.0012	.0220	.0202	.0018	.28	.0050	.0001	0.53	0.5
47935	Nov. 2	Slight.	Slight.	.36	5.25	1.70	.0018	.0180	.0148	.0032	.42	.0170	.0001	0.49	1.6
48407	Dec. 14	Decided.	Slight.	.70	4.20	1.85	.0052	.0190	.0148	.0042	.30	.0040	.0002	0.73	0.8
Av.*.	....	....	....	.50	3.70	1.63	.0024	.0181	.0146	.0035	.27	.0072	.0001	0.62	0.8

Charles River after Filtration.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1903.												
44130	Feb. 9	None.	None.	.30	3.60	.0020	.0110	.22	.0040	.0000	.45	0.3	.0130
44230	Feb. 16	V. slight.	V. slight.	.33	3.50	.0012	.0066	.24	.0030	.0000	.44	0.6	.0150
44294	Feb. 23	None.	None.	.23	3.30	.0020	.0106	.27	.0100	.0001	.36	0.8	.0150
44620	Mar. 17	V. slight.	None.	.31	4.00	.0032	.0118	.25	.0030	.0001	.49	0.8	.0130
44984	Apr. 15	V. slight.	V. slight.	.12	5.50	.0020	.0092	.28	.0470	.0003	.18	1.7	.0130
45340	May 15	Slight.	V. slight	.23	3.80	.0068	.0126	.34	.0300	.0001	.40	1.4	.0100
45837	June 16	V. slight.	Slight.	.23	4.50	.0038	.0110	.24	.0100	.0017	.41	1.4	.0110
46236	July 13	V. slight.	None.	.32	3.80	.0004	.0080	.25	.0130	.0006	.47	1.3	.0120
46702	Aug. 11	Slight.	V. slight.	.22	4.50	.0006	.0054	.27	.0200	.0000	.43	1.6	.0550
47119	Sept. 9	Slight.	V. slight.	.20	3.60	.0010	.0168	.28	.0090	.0000	.46	0.6	.0100
48408	Dec. 14	V. slight.	None.	.48	3.10	.0030	.0134	.31	.0070	.0000	.53	1.1	.0400
Av.*.	....	....	....	.27	4.03	.0025	.0108	.27	.0161	.0003	.42	1.2	.0198

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

WATER SUPPLY OF MILLBURY. — MILLBURY WATER COMPANY.

Well.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 9 samples collected in 1903.	.01	4.56	-	.0004	.0023	-	-	.25	.0131	.0000	.05	2.0	.0064

WATER SUPPLY OF MILTON.

(See *Metropolitan Water District*, pages 138-141.)

WATER SUPPLY OF MONSON.

Well.

	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 9 samples collected in 1903.	.00	3.57	-	.0009	.0011	-	-	.11	.0121	.0000	.01	0.9	.0072

MONSON (HOSPITAL FOR EPILEPTICS).

Waters examined in Connection with Advice to the Trustees of the State Hospital for Epileptics. (See also page 51.)

[Parts per 100,000.]

		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as				
								Albuminoid.								
Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1902.															
43588	Dec. 26	V. slight.	V. slight.	.09	2.40	.75	.0016	.0078	.0068	.0010	.19	.0130	.0001	.20	0.8	-
	1903.															
43706	Jan. 6	None.	V. slight.	.00	2.95	.80	.0004	.0082	.0070	.0012	.20	.0130	.0000	.23	1.0	-
46144	July 7	None.	V. slight.	.00	4.20	-	.0004	.0024	-	-	.12	.0040	.0000	.04	1.7	.0010
46213	July 10	V. slight.	Slight.	.02	3.60	-	.0006	.0022	-	-	.14	.0000	.0000	.04	1.4	.0100
46214	July 10	None.	V. slight.	.00	5.30	-	.0000	.0006	-	-	.14	.0000	.0000	.05	0.6	.0010

The first two samples were collected from West Reservoir; the others, from springs above the proposed new hospital buildings.

MONTAGUE.

Water Supply of Montague. — Turner's Falls Fire District.

(See also pages 52, 53.)

Lake Pleasant.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.03	2.39	0.65	.0014	.0064	.0056	.0008	0.12	.0022	.0000	.10	0.2	-

Water Supply of Nahant.

(See *Metropolitan Water District*, pages 138-141.)

Water Supply of Nantucket. — Wannacomet Water Company:

Wannacomet Pond.

Average of 4 samples collected in 1903.	.06	6.41	1.81	.0026	.0168	.0123	.0045	2.21	.0015	.0000	.14	1.4	-

Wells near Wannacomet Pond.

Average of 3 samples collected in 1903.	.07	6.33	-	.0048	.0091	-	-	2.10	.0073	.0000	.09	1.2	.0353
Average of two previous years, .	.03	6.88	-	.0055	.0048	-	-	2.23	.0140	.0001	.07	1.5	.0158

Waters examined in Connection with Advice relative to a Proposed Water Supply for the Village of Siasconset. (See also pages 53, 56.)

[Parts per 100,000.]

		Appearance.				Ammonia.			Nitrogen as				
Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue on Evaporation.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1903.												
44841	Apr. 2	V. slight.	V. slight.	.00	5.20	.0002	.0022	1.80	.0070	.0000	.05	0.3	.0210
44842	Apr. 2	V. slight.	V. slight.	.00	5.50	.0006	.0018	1.80	.0110	.0000	.06	0.3	.0230
44923	Apr. 10	V. slight.	V. slight.	.00	5.00	.0002	.0018	1.74	.0140	.0000	.01	0.3	.0520

The samples were collected from test wells in the golf grounds west of Siasconset.

Water examined in Connection with Advice to R. E. Burgess. (See also page 56.)

46436	July 23	None.	None.	.00	10.30	.0010	.0006	1.44	.0000	.0000	.01	4.6	.0010

The sample was collected from Shawaukemma Spring.

Water Supply of Natick.

Well.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 9 samples collected in 1903.	.01	7.98	-	.0003	.0013	-	-	.46	.0256	.0000	.03	4.2	.0049

Water examined in Connection with Advice to E. Edwards & Sons. (See also page 56.)

[Parts per 100,000.]

		Appearance.				Ammonia.			Nitrogen as				
Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue on Evaporation.	Free.	Albu-minoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1903.												
46422	July 22	None.	None.	.01	27.10	.0006	.0046	2.02	1.7500	.0003	.05	9.4	.0080

The sample was collected from a well at the factory of E. Edwards & Sons.

Water Supply of Needham.

Well No. 1.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 6 samples collected in 1903.	.00	5.37	-	.0005	.0016	-	-	.54	.1258	.0000	.02	2.0	.0038

Well No. 2.

Average of 6 samples collected in 1903.	.00	5.43	-	.0005	.0016	-	-	.55	.1128	.0000	.02	2.0	.0055

NEEDHAM.

Water examined in Connection with Advice relative to Additional Water Supply.

(See also page 57.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
46336	1903. July 17	None.	Slight.	.08	4.40	1.80	.0020	.0094	.0046	.0048	.45	.0700	.0000	.17	1.3

The sample was collected from Hicks Spring.

Water Supply of New Bedford.

Old Storage Reservoir.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.			
Average of 4 samples collected in 1903.	.95	4.75	2.16	.0038	.0227	.0200	.0027	.54	.0017	.0001	.92	0.8	-

Little Quittacas Pond, Lakeville.

Average of 4 samples collected in 1903.	.23	3.21	1.41	.0017	.0158	.0130	.0028	.48	.0007	.0000	.49	0.6	-

Great Quittacas Pond, Lakeville.

Average of 4 samples collected in 1903.	.44	3.28	1.59	.0023	.0184	.0155	.0029	.48	.0012	.0001	.67	0.7	-

Water Supply of Newburyport.

Well.

Average of 10 samples collected in 1903.	.09	6.22	-	.0003	.0031	-	-	.46	.0239	.0000	.06	2.5	.0374
Average of ten previous years, .	.12	6.39	-	.0005	.0041	-	-	.64	.0203	.0000	.09	2.4	.0279

NEWBURYPORT.

Waters examined in Connection with Advice relative to Additional Water Supply.
(See also page 58.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.			
	1903.															
44455	Mar. 6	None.	V. slight.	.02	5.90	-	.0006	.0046	-	-	.50	.0150	.0001	.08	2.1	.0140
44453	Mar. 6	Slight.	None.	.17	9.40	-	.0000	.0002	-	-	.42	.0000	.0000	.01	4.4	.0560
44454	Mar. 6	Slight.	None.	.18	9.00	-	.0000	.0006	-	-	.40	.0010	.0001	.01	4.3	.0800
44456	Mar. 6	V. slight.	V. slight.	.32	4.20	1.95	.0018	.0168	.0156	.0012	.41	.0020	.0000	.45	1.8	-

The first sample was collected from Jackman Spring; the next two, from tubular wells near the basin at the pumping station; the last, from Artichoke River, at the outlet of the mill pond.

Water Supply of Newton.

Wells and Filter Gallery.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 8 samples collected in 1903.	.03	5.99	-	.0007	.0029	-	-	.43	.0404	.0000	.11	2.7	.0095

Water Supply of North Adams.

Notch Brook Storage Reservoir.

Average of 4 samples collected in 1903.	.01	6.59	1.41	.0086	.0084	.0064	.0020	.07	.0037	.0009	.13	4.9	-

Broad Brook, in Pownal, Vt.

Average of 4 samples collected in 1903.	.05	3.51	1.42	.0024	.0046	.0041	.0005	.07	.0177	.0000	.19	2.0	-

NORTH ADAMS.

Water examined in Connection with Advice to G. L. Rice, M.D. (See also page 60.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
45272	1903. May 11	None.	None.	.00	8.70	.0006	.0006	.06	.0100	.0000	.01	6.7	.0110

The sample was collected from White Diamond Spring, on land of G. L. Rice, M.D.

Water Supply of Northampton.

Middle Storage Reservoir on Roberts' Meadow Brook.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 5 samples collected in 1903.	.13	3.75	1.14	.0013	.0100	.0088	0012	.11	.0034	.0000	.27	1.7	-

Mountain Street Reservoir, at Inlet.

Average of 6 samples collected in 1903.	.03	4.32	1.08	.0010	.0064	.0050	.0014	.09	.0063	.0000	.11	1.9	-

Mountain Street Reservoir, at Surface.

Average of 6 samples collected in 1903.	.05	3.49	0.98	.0017	.0080	.0059	.0021	.09	.0085	.0000	.14	1.6	-

Mountain Street Reservoir, at Bottom.

Average of 6 samples collected in 1903.	.06	3.52	0.92	.0029	.0077	.0056	.0021	.10	.0067	.0000	.13	1.7	-

Water Supply of North Andover.

Great Pond.

Average of 4 samples collected in 1903.	.13	3.71	1.42	.0020	.0196	.0158	.0038	.32	.0020	.0001	.35	1.1	-

NORTH ATTLEBOROUGH.

Water Supply of North Attleborough.

Well.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 7 samples collected in 1903.	.00	6.13	-	.0005	.0018	-	-	.63	.0579	.0000	.02	2.7	.0083

Water Supply of Northborough.

Lower Reservoir.

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.67	3.71	1.56	.0034	.0206	.0164	.0042	.24	.0047	.0000	.60	0.9	-

Water Supply of Northbridge. — Whitin Machine Works.

Cook Allen Brook above Storage Reservoir.

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 8 samples collected in 1903.	.23	2.85	1.03	.0004	.0086	.0073	.0013	.22	.0013	.0000	.36	0.2	-

Reservoir on Cook Allen Brook.

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 5 samples collected in 1903.	.28	3.03	1.27	.0019	.0123	.0107	.0016	.19	.0016	.0000	.45	0.3	-

Water Supply of North Brookfield.

Doane Pond.

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.45	3.00	1.20	.0072	.0201	.0155	.0046	.17	.0045	.0001	.46	0.6	-

North Pond.

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.57	3.49	1.45	.0031	.0261	.0203	.0058	.16	.0055	.0000	.60	0.5	-

Water Supply of Northfield. — Northfield Water Company.

Reservoir.

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.10	2.95	0.97	.0011	.0113	.0104	.0009	.11	.0020	.0001	.23	0.7	-

NORTHFIELD.

Waters examined in Connection with Advice relative to the Water Supply of East Northfield. (See also page 60.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1903.												
47877	Oct. 29	Slight.	V. slight.	.01	4.30	.0008	.0012	.14	.0210	.0000	.12	1.4	.0850
47878	Oct. 29	V. slight.	V. slight.	.40	4.30	.0084	.0026	.15	.0150	.0000	.13	2.2	.2200
47879	Oct. 29	V. slight.	V. slight	.23	4.70	.0064	.0022	.17	.0130	.0001	.12	2.2	.2600

The samples were collected from test wells in the low land bordering the Connecticut River.

Water Supply of Norwood.

Buckmaster Pond, Dedham.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 12 samples collected in 1903.	.09	3.13	1.04	.0048	.0148	.0125	.0023	.37	.0027	.0000	.20	0.8	-

Water Supply of Palmer Fire District. — Palmer Water Company.

Lower Reservoir.

Average of 4 samples collected in 1903.	.36	3.19	1.05	.0012	.0123	.0100	.0023	.13	.0025	.0000	.40	0.5	-

Water Supply of Peabody. (See also page 61.)

Brown's Pond.

Average of 4 samples collected in 1903.	.15	3.21	1.30	.0010	.0148	.0123	.0025	.53	.0037	.0001	.32	0.7	-

Spring Pond.

Average of 4 samples collected in 1903.	.03	4.02	1.36	.0053	.0120	.0098	.0022	.62	.0020	.0000	.18	1.6	-

Water Supply of Pittsfield. (See also page 61.)

Sacket Brook Reservoir.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.08	5.81	1.46	.0005	.0051	.0041	.0010	.08	.0147	.0000	.16	4.5	-

Ashley Lake.

Average of 5 samples collected in 1903.	.33	4.59	2.04	.0089	.0222	.0192	.0030	.16	.0032	.0001	.54	2.3	-

Ashley Brook Reservoir.

Average of 4 samples collected in 1903.	.21	5.34	1.99	.0028	.0119	.0107	.0012	.08	.0070	.0000	.85	3.9	-

Hathaway Brook Reservoir.

Average of 4 samples collected in 1903.	.05	7.81	2.01	.0009	.0048	.0043	.0005	.09	.0137	.0000	.13	6.6	-

Mill Brook Reservoir.

Average of 4 samples collected in 1903.	.06	4.89	1.33	.0005	.0045	.0039	.0006	.06	.0062	.0000	.14	3.4	-

Water Supply of Plymouth.

Little South Pond.

Average of 4 samples collected in 1903.	.03	2.34	0.88	.0013	.0130	.0110	.0020	.69	.0017	.0000	.09	0.1	-

Water examined in Connection with Advice to the Plymouth Mills. (See also page 61.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
46207	1903. July 10	None.	None.	.00	5.10	.0000	.0012	1.00	.0030	.0000	.00	1.4	.0020

The sample was collected from a well at the Plymouth Mills.

PROVINCETOWN.

Water Supply of Provincetown.

Open Basin.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 6 samples collected in 1903	-	11.43	-	.0159	.0172	-	-	2.54	.0033	.0001	.85	3.1	.4713
Average of 5 previous years,	.92	10.46	-	.0121	.0182	-	-	2.59	.0057	.0001	.72	2.5	.3681

Water Supply of Quincy.

(See *Metropolitan Water District*, pages 138–141.)

Water Supply of Randolph and Holbrook.

Great Pond in Randolph and Braintree.

Average of 4 samples collected in 1903.	.46	4.11	1.74	.0017	.0177	.0162	.0015	0.56	.0057	.0001	.59	1.1	-

Water Supply of Reading. (See also page 62.)

Filter Gallery.

Average of 23 samples collected in 1903.	.67	7.59	-	.0107	.0113	-	-	0.46	.0028	.0000	.61	2.6	.1715
Average of eleven previous years,	.62	10.22	-	.0078	.0106	-	-	0.52	.0043	.0000	.47	3.7	.2142

Water of Filter Gallery after passing through the Mechanical Filter.

Average of 21 samples collected in 1903.	.22	15.57	-	.0060	.0079	-	-	0.45	.0037	.0006	.35	9.3	.0086
Average of six previous years,	.22	15.99	-	.0049	.0085	-	-	0.46	.0058	.0011	.32	9.5	.0099

Water Supply of Revere.

(See *Metropolitan Water District*, pages 138–141.)

Water Supply of Rockland. (See also page 5.)

(See *Abington*.)

Water Supply of Rockport. (See also page 64.)

Cape Pond.

Average of 4 samples collected in 1903.	.25	7.84	2.70	.0101	.0268	.0195	.0073	3.11	.0230	.0001	.44	1.3	-

RUSSELL.

Water examined in Connection with Advice relative to a Proposed Water Supply.

(See also page 66.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
45168	1903. Apr. 30	None.	V. slight.	.12	2.60	0.85	.0002	.0054	.0050	.0004	.11	.0010	.0000	.20	0.8

The sample was collected from Black Brook, at the site of the proposed reservoir.

Water examined in Connection with Advice to the Woronoco Paper Company.

(See also page 67.)

43787	1903. Jan. 13	V. slight.	V. slight.	.11	2.60	1.00	.0032	.0128	.0116	.0012	.16	.0050	.0000	.26	1.3

The sample was collected from Potash Brook, and represents water from the brook which has passed through mechanical filters.

WATER SUPPLY OF RUTLAND.

Muschopauge Lake.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 5 samples collected in 1903.	0.04	1.96	0.63	.0014	.0096	.0086	.0010	.18	.0028	.0000	.15	0.6	-
Average of six previous years, .	0.06	2.26	0.85	.0027	.0150	.0126	.0024	.17	.0026	.0000	.17	0.5	-

WATER SUPPLY OF SALEM AND BEVERLY.

Wenham Lake in Beverly and Wenham.

Average of 12 samples collected in 1903.	0.19	5.70	1.91	.0046	.0183	.0142	.0041	.76	.0063	.0002	.33	2.2	-
Average of twelve previous years,	0.11	5.67	1.57	.0031	.0175	.0138	.0037	.77	.0060	.0001	.26	2.4	-

Longham Brook in Beverly and Wenham.

Average of 12 samples collected in 1903.	0.94	6.16	2.36	.0076	.0287	.0233	.0054	.91	.0154	.0002	.78	1.8	-
Average of six previous years, .	1.06	6.30	2.57	.0082	.0368	.0311	.0057	.89	.0127	.0002	.94	1.7	-

SALEM AND BEVERLY.

Water examined in Connection with Advice to the Authorities of the City of Salem.

(See also page 68.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
48367	1903. Dec. 8	None.	V. slight.	.00	10.60	.0020	.0026	1.05	.2600	.0000	.01	5.6	.0030

The sample was collected from Liberty Hill Spring in Salem.

Water Supply of Saugus.

(See *Lynn*.)

Water Supply of Scituate. — Scituate Water Company.

Wells.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 9 samples collected in 1903.	.00	15.33	-	.0003	.0007	-	-	3.64	.1800	.0000	.02	4.4	.0067

Water Supply of Sharon. (See also pages 68, 70.)

Well.

Average of 8 samples collected in 1903.	.00	9.13	-	.0004	.0011	-	-	1.13	.2521	.0001	.02	3.5	.0069

Water Supply of Sheffield. — Sheffield Water Company.

Spring.

Average of 6 samples collected in 1903.	.00	8.22	-	.0005	.0017	-	-	0.07	.0053	.0000	.02	1.7	.0047

Water Supply of Somerville.

(See *Metropolitan Water District*, pages 138–141.)

WATER SUPPLY OF SOUTHBRIDGE. — SOUTHBRIDGE WATER SUPPLY COMPANY.

Hatchet Brook Storage Reservoir.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.35	2.85	1.11	.0013	.0140	.0117	.0023	.15	.0072	.0000	.49	0.8	-
Average of six previous years, .	.45	3.30	1.50	.0028	.0211	.0170	.0041	.15	.0023	.0000	.56	0.6	-

Waters examined in Connection with Advice to the American Optical Company. (See also page 71.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1903.												
44931	Apr. 10	None.	None.	.00	18.80	.0008	.0036	2.80	1.0800	.0000	.04	5.1	.0130
45479	May 21	None.	None.	.00	19.80	.0006	.0022	2.18	0.7500	.0000	.01	-	.0500
44932	Apr. 10	V. slight.	Cons.	.03	18.60	.0132	.0034	1.59	0.4000	.0002	.08	7.1	.0330
45478	May 22	V. slight.	Cons.	.01	10.60	.0006	.0118	0.75	0.1500	.0001	.20	-	.0560
45477	May 22	Slight.	Cons.	.02	5.00	.0004	.0066	0.18	0.0110	.0000	.12	-	.0220

The first two samples were collected from a driven well in the main factory of the American Optical Company; the next two, from a well at the machine shop in Lensdale; the last, from a spring on the north side of the factory at Lensdale.

SOUTH HADLEY.

Waters examined in Connection with Advice to the School Committee. (See also page 72.)

	1903.												
48357	Dec. 7	Slight.	Cons.	.08	10.20	.0010	.0012	0.34	0.0880	.0003	.02	4.8	.1100
48358	Dec. 7	V. slight.	Cons.	.05	14.50	.0018	.0032	0.35	0.4000	.0008	.09	3.3	.2600

The first sample was collected from a well in the cellar of a schoolhouse at South Hadley Centre; the last, from a well at a schoolhouse in South Hadley Plains.

SOUTH HADLEY FALLS FIRE DISTRICT.

Water Supply of South Hadley Falls Fire District.

Leaping Well Reservoir.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Sus-pended.						
Average of 4 samples collected in 1903.	.04	2.51	0.84	.0018	.0128	.0095	.0033	.14	.0025	.0000	.14	0.4	-

Buttery Brook Reservoir.

Average of 4 samples collected in 1903.	.23	3.91	1.27	.0036	.0155	.0119	.0036	.26	.0337	.0004	.33	1.0	-

Water Supply of Spencer.

Shaw Pond.

Average of 4 samples collected in 1903.	.03	2.22	0.76	.0011	.0102	.0099	.0003	.15	.0032	.0000	.10	0.7	-

Water Supply of Springfield and Ludlow. (See also page 75.)

Ludlow Reservoir.

Average of 11 samples collected in 1903.	.22	2.68	1.17	.0029	.0235	.0145	.0090	.12	.0017	.0000	.33	0.6	-
Average of eight previous years,	.27	3.08	1.42	.0032	.0339	.0206	.0133	.14	.0036	.0000	.38	0.9	-

Jabish Brook Canal, Ludlow.

Average of 11 samples collected in 1903.	.35	3.27	1.33	.0015	.0146	.0127	.0019	.14	.0041	.0001	.43	0.9	-
Average of two previous years, .	.37	3.49	1.42	.0024	.0170	.0141	.0029	.14	.0050	.0000	.48	1.0	-

Chapin Pond, Ludlow.

Average of 4 samples collected in 1903.	.04	2.20	1.16	.0009	.0184	.0159	.0025	.10	.0012	.0000	.22	0.4	-

Five Mile Pond.

Average of 4 samples collected in 1903.	.07	2.33	1.09	.0040	.0187	.0169	.0018	.15	.0017	.0001	.26	0.4	-

Loon Pond.

Average of 4 samples collected in 1903.	.04	2.65	1.02	.0034	.0169	.0144	.0025	.21	.0027	.0001	.20	0.7	-

SPRINGFIELD AND LUDLOW.

Spring Waters examined in Connection with Advice to the Authorities of the City of Springfield. (See also page 73.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1903.												
47848	Oct. 27	None.	None.	.00	16.50	.0004	.0098	1.64	1.0000	.0000	.02	6.6	.0030
47849	Oct. 27	None.	V. slight.	.00	5.80	.0008	.0014	0.38	0.2500	.0001	.02	2.3	.0050
47850	Oct. 27	None.	None.	.00	20.40	.0000	.0022	1.89	0.5800	.0000	.02	8.4	.0030
47851	Oct. 27	None.	V. slight.	.00	16.50	.0000	.0048	1.90	0.9500	.0002	.03	4.7	.0050
48026	Nov. 10	None.	None.	.00	16.30	.0010	.0048	1.87	0.7000	.0002	.00	5.3	.0010
47846	Oct. 27	None.	None.	.00	8.20	.0006	.0018	0.26	0.0550	.0000	.03	5.0	.0050
47915	Nov. 2	None.	V. slight.	.00	8.80	.0012	.0028	0.27	0.0650	.0000	.02	5.1	.0010
47847	Oct. 27	None.	None.	.00	16.80	.0000	.0012	0.84	0.2700	.0000	.02	8.3	.0060
47916	Nov. 2	V. slight.	V. slight.	.00	20.00	.0000	.0006	1.14	0.2000	.0000	.01	9.1	.0010
47780	Oct. 26	None.	None.	.00	9.80	.0004	.0026	0.83	0.3500	.0001	.01	3.8	.0010
48134	Nov. 18	None.	V. slight.	.00	9.70	.0004	.0020	0.84	0.3500	.0000	.03	3.8	.0010
47781	Oct. 26	None.	None.	.00	4.00	.0002	.0014	0.08	0.0080	.0000	.01	2.3	.0030
47852	Oct. 27	None.	None.	.00	3.50	.0000	.0004	0.10	0.0050	.0000	.04	2.3	.0030
47918	Nov. 2	Slight.	Cons.	.07	12.70	.0008	.0042	1.21	0.0100	.0008	.03	6.0	.0450
48029	Nov. 10	Slight.	Slight.	.11	13.00	.0022	.0064	1.25	0.0200	.0002	.06	6.3	.0750
47028	Nov. 10	None.	None.	.00	7.90	.0002	.0014	0.33	0.3850	.0001	.06	3.3	.0010
47919	Nov. 2	None.	V. slight.	.01	5.20	.0006	.0012	0.39	0.0050	.0000	.01	1.6	.0150
48055	Nov. 10	None.	Slight.	.01	3.60	.0008	.0010	0.40	0.0020	.0000	.01	2.0	.0450
47917	Nov. 2	None.	V. slight.	.00	4.40	.0006	.0024	0.83	0.0050	.0004	.02	1.0	.0180
48027	Nov. 10	None.	V. slight.	.01	21.50	.0008	.0046	1.84	1.3000	.0001	.05	6.6	.0010
47921	Nov. 2	None.	None.	.00	10.60	.0158	.0010	0.12	0.0050	.0000	.02	5.4	.0010
48053	Nov. 11	None.	V. slight.	.00	10.50	.0172	.0014	0.14	0.0000	.0001	.01	5.0	.0030
48054	Nov. 11	None.	V. slight.	.00	34.80	.0002	.0026	2.57	0.9800	.0000	.01	14.9	.0050
48052	Nov. 11	Slight.	Cons.	.05	6.00	.0018	.0026	0.15	0.0020	.0001	.01	3.0	.1200
47920	Nov. 2	None.	None.	.00	6.70	.0456	.0024	0.38	0.3350	.0026	.01	1.6	.0030

No. 47848 was collected from Pecousic Spring; No. 47849, from Parkwood Spring; No. 47850, from Wesson's Spring; Nos. 47851 and 48026, from Water's Spring; Nos. 47846 and 47915, from Wilbraham Mountain Spring; Nos. 47847 and 47916, from Hygeia Spring; Nos. 47780 and 48134, from Ingersoll Grove Spring; Nos. 47781 and 47852, from Massasoit Spring; Nos. 47918 and 48029, from a well in Benton Park; No. 47028, from Collins' Farm Spring; Nos. 47919 and 48055, from Indian Spring; No. 47917, from Swan Pond Spring; No. 48027, from Spring No. 2, at the corner of Hancock and Hickory streets; Nos. 47921 and 48053, from a well at the railroad station; No. 48054, from a spring near the railroad bridge; No. 48052, from Iroquois Spring; No. 47920, from a spring in Forest Park.

STERLING.

Water examined in Connection with Advice to John H. Coughlin. (See also page 75.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
45901	1903. June 19	None.	None.	.00	12.60	.0022	.0030	.70	.5300	.0002	.04	6.3	.0050

The sample was collected from a well used for the water supply of the Sterling Inn.

WATER SUPPLY OF STOCKBRIDGE. — STOCKBRIDGE WATER COMPANY.

Lake Averic.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 4 samples collected in 1903.	.12	6.02	1.50	.0025	.0157	.0122	.0035	.07	.0025	.0001	.26	4.0	-

WATER SUPPLY OF STONEHAM.

(See *Metropolitan Water District*, pages 138–141.)

WATER SUPPLY OF STOUGHTON. (See also page 75.)

Well.

Average of 6 samples collected in 1903.	.20	3.28	-	.0012	.0074	-	-	.31	.0043	.0001	.28	0.8	.0093

WATER SUPPLY OF SWAMPSCOTT.

(See *Metropolitan Water District*, pages 138–141.)

WATER SUPPLY OF TAUNTON.

Assawompsett Pond, Lakeville.

Average of 4 samples collected in 1903.	.31	3.02	1.40	.0023	.0164	.0143	.0021	.47	.0005	.0000	.53	0.5	-

TAUNTON.

Elder's Pond, Lakeville.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Sus-pended.						
Average of 4 samples collected in 1903.	.04	2.76	1.06	.0012	.0159	.0138	.0021	0.46	.0007	.0000	.29	0.6	-

Long Pond, Lakeville.

Average of 4 samples collected in 1903.	.72	3.81	1.99	.0017	.0189	.0166	.0023	0.47	.0012	.0001	.94	0.4	-

Water Supply of Tewksbury State Hospital.

Wells.

Average of 6 samples collected in 1903.	.01	3.97	-	.0002	.0010	-	-	0.35	.0267	.0000	.02	1.2	.0047

Water Supply of Tisbury. — Vineyard Haven Water Company.

Spring.

Average of 4 samples collected in 1903.	.01	4.27	-	.0006	.0013	-	-	1.05	.0047	.0000	.01	0.6	.0177

Water Supply of Uxbridge.

Water examined in Connection with Advice relative to Additional Water Supply.
(See also page 77.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1903.												
48406	Dec. 14	None.	V. slight.	.00	9.30	.0504	.0042	1.26	.3500	.0005	.06	3.3	.0230
48412	Dec. 15	None.	V. slight.	.00	8.20	.0576	.0038	1.26	.3150	.0006	.04	3.3	.0230

The samples were collected from a well in the Capron mill yard.

WAKEFIELD.

Water Supply of Wakefield.

Crystal Lake.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Suspended.						
Average of 4 samples collected in 1903.	.20	4.50	1.55	.0030	.0165	.0145	.0020	.56	.0057	.0001	.31	2.0	-

Water Supply of Walpole.

Tubular Wells.

Average of 12 samples collected in 1903.	.00	3.81	-	.0001	.0006	-	-	.33	.0202	.0000	.00	1.1	.0102

Water Supply of Waltham.

Well and Filter Gallery.

Average of 13 samples collected in 1903.	.05	7.20	-	.0030	.0031	-	-	.58	.0277	.0000	.10	3.5	.0305
Average of eleven previous years,	.03	7.05	-	.0031	.0031	-	-	.54	.0236	.0000	.07	3.3	.0110

Water examined in Connection with Advice to the City Authorities. (See also page 78.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1903.												
47531	Oct. 8	None.	None.	.02	6.90	.0012	.0024	.41	.0800	.0000	.03	2.7	.0030
47712	Oct. 21	None.	None.	.00	6.20	.0012	.0012	.37	.0550	.0000	.01	2.9	.0020
47532	Oct. 8	None.	None.	.02	6.60	.0000	.0024	.41	.0800	.0000	.05	2.7	.0040
47713	Oct. 21	None.	None.	.00	6.80	.0006	.0018	.40	.0590	.0000	.01	2.9	.0010

The first two samples were collected from Constitution Spring; the last two, from a carboy filled with water from the spring.

Water Supply of Ware.

Well.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 8 samples collected in 1903.	.00	8.90	-	.0004	.0009	-	-	.75	.3162	.0000	.01	3.1	.0032

Water Supply of Onset Bay Fire District, Wareham. — Onset Water Company.

Jonathan's Pond.

Average of 4 samples collected in 1903.	.01	2.32	.96	.0010	.0085	.0074	.0011	.70	.0002	.0000	.11	0.0	-

Water Supply of Watertown.

(See *Metropolitan Water District*, pages 138-141.)

Water Supply of Wayland. (See also page 79.)

Faucet in Wayland.

Average of 4 samples collected in 1903.	.65	4.39	-	.0029	.0181	-	-	.30	.0127	.0001	.63	1.7	.0530
Average of 4 samples collected in 1902.	.60	4.94	-	.0024	.0219	-	-	.33	.0640	.0000	.61	1.8	.0297

Water Supply of Webster.

Well.

Average of 7 samples collected in 1903.	.01	3.79	-	.0008	.0011	-	-	.25	.0394	.0000	.03	1.7	.0116

Water Supply of Wellesley.

Filter Gallery.

October, 1903,	.02	6.20	-	.0008	.0032	-	-	.38	.1200	.0000	.08	2.9	.0020

Well at Williams Spring.

Average of 3 samples collected in 1903.	.01	11.27	-	.0005	.0012	-	-	.86	.5200	.0000	.03	3.6	.0037

WELLESLEY.

Tubular Wells.

[Parts per 100,000]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 8 samples collected in 1903.	.00	7.64	-	.0003	.0010	-	-	.60	.1625	.0000	.02	3.3	.0076

Water examined in Connection with Advice to the Trustees of Wellesley College.
(See also page 80)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1903.												
47738	Oct. 22	Slight.	V. slight.	.05	4.90	.0000	.0006	.29	.0580	.0001	.02	1.6	.0320
47745	Oct. 23	V. slight.	V. slight.	.00	4.30	.0004	.0004	.28	.0500	.0000	.03	1.7	.0130

The samples were collected from a driven well in the college grounds.

Water Supply of Westborough.

Lower Sandra Pond.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.02	2.55	0.81	.0004	.0055	.0048	.0007	.18	.0017	.0000	.07	1.2	-

Water Supply of Westfield.

Montgomery Storage Reservoir.

Average of 4 samples collected in 1903.	.43	2.22	1.06	.0011	.0141	.0119	.0022	.11	.0015	.0000	.47	0.2	-
Average of seven previous years,	.55	2.71	1.35	.0031	.0223	.0181	.0042	.11	.0034	.0000	.64	0.4	-

WESTFIELD.

Tillottson Brook Reservoir, Granville.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.07	2.53	0.64	.0011	.0083	.0068	.0015	.10	.0017	.0000	.15	0.5	-
Average of five previous years, .	.10	2.64	0.79	.0007	.0058	.0050	.0008	.12	.0038	.0000	.19	0.5	-

WESTFORD.

Water examined in Connection with Advice to Caleb L. Smith. (See also page 81.)

[Parts per 100,000.]

		Appearance.				Ammonia.			Nitrogen as				
Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue on Evaporation.	Free.	Albu-minoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
46248	1903. July 14	None.	None.	.00	2.20	.0000	.0006	.15	.0000	.0000	.00	0.2	.0020

The sample was collected from a spring in Westford.

WATER SUPPLY OF WESTON. — WESTON AQUEDUCT COMPANY.

Well.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid.								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 7 samples collected in 1903.	.06	7.13	-	.0005	.0035	-	-	.43	.0469	.0000	.12	3.0	.0083

WATER SUPPLY OF WEST SPRINGFIELD.

Darby Brook Storage Reservoir.

Average of 4 samples collected in 1903.	.10	4.72	1.42	.0091	.0172	.0087	.0085	.19	.0052	.0001	.21	2.3	-

WEST SPRINGFIELD.

Receiving Well.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.02	7.00	-	.0004	.0011	-	-	.42	.2280	.0000	.01	2.4	.0040

WESTWOOD.

Water examined in Connection with Advice to the School Committee. (See also page 81.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1903.												
45024	Apr. 21	None.	None.	.00	4.00	.0008	.0034	.28	.0080	.0000	.12	1.1	.0030
45229	May 6	None.	V. slight.	.00	3.40	.0000	.0036	.20	.0050	.0000	.01	1.3	.0020

The samples were collected from a well at the Colburn School.

WATER SUPPLY OF WEYMOUTH. (See also page 82.)

Great Pond.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.73	3.73	1.84	.0029	.0167	.0152	.0015	0.46	.0025	.0001	.84	0.4	-

WATER SUPPLY OF WHITMAN.

Hobart's Pond.

Average of 4 samples collected in 1903.	.56	6.94	2.58	.0052	.0328	.0285	.0043	1.03	.0040	.0002	.79	1.9	-
Average of eight previous years,	.62	5.89	2.20	.0028	.0326	.0235	.0041	0.84	.0088	.0001	.76	1.7	-

WILBRAHAM.

Water examined in Connection with Advice to L. E. Taft. (See also page 82.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1903.												
45361	May 18	None.	V. slight.	.00	9.30	.0008	.0020	.27	.0800	.0001	.01	4.6	.0050

The sample was collected from Wilbraham Mountain Spring.

WILLIAMSBURG.

Waters examined in Connection with Advice relative to a Proposed Water Supply. (See also pages 83, 84.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1903.														
44596	Mar. 11	V. slight.	Slight.	.18	2.55	0.95	.0002	.0064	.0054	.0010	.06	.0010	.0000	.27	1.0
45433	May 19	None.	V. slight.	.02	4.00	1.15	.0012	.0046	.0042	.0004	.08	.0020	.0000	.11	2.0
44595	Mar. 11	Decided.	Cons.	.24	1.90	0.80	.0002	.0094	.0062	.0032	.06	.0010	.0000	.37	0.6
45434	May 19	V. slight.	Cons.	.24	4.10	1.35	.0004	.0116	.0102	.0014	.07	.0020	.0001	.39	1.4

The first two samples were collected from Unquomonk Brook; the last two, from Meekins Brook.

WATER SUPPLY OF WILLIAMSTOWN. — WILLIAMSTOWN WATER COMPANY.

(See also page 85.)

Cold Spring.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
					Albuminoid.								
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.			
Average of 4 samples collected in 1903.	.00	12.52	-	.0003	.0009	-	-	.05	.0362	.0000	.04	11.8	.0037

WILLIAMSTOWN.

Sherman Spring.

[Parts per 100,000.]

	Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.00	9.70	-	.0006	.0038	-	-	.06	.0102	.0000	.05	6.6	.0052

Flora Glen Reservoir.

	Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.01	4.55	0.70	.0011	.0077	.0059	.0018	.07	.0032	.0000	.08	3.0	-

Paul Brook Reservoir.

	Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.01	4.81	0.94	.0007	.0052	.0041	.0011	.06	.0055	.0000	.08	3.4	-

Water Supply of Winchendon.

Well.

	Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 7 samples collected in 1903.	.01	2.97	-	.0029	.0027	-	-	.11	.0050	.0000	.06	0.8	.0156
Average of six previous years, .	.02	3.19	-	.0008	.0014	-	-	.11	.0041	.0000	.03	1.1	.0093

Water Supply of Winchester.

North Reservoir.

	Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.05	4.09	1.51	.0033	.0231	.0177	.0054	.40	.0015	.0001	.25	1.7	-

South Reservoir.

	Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.08	2.97	1.27	.0053	.0178	.0164	.0014	.28	.0020	.0002	.20	1.1	-

Middle Reservoir.

	Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 4 samples collected in 1903.	.16	3.16	1.36	.0020	.0241	.0197	.0044	.30	.0027	.0001	.34	1.0	-

Water Supply of Winthrop.

(See *Metropolitan Water District*, pages 138-141.)

Water Supply of Woburn. (See also page 86.)

Filter Gallery.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as				
					Albuminoid								
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of 15 samples collected in 1903.	.00	9.81	-	.0067	.0029	-	-	1.18	.0204	.0000	.05	5.1	.0052
Average of twelve previous years,	.01	10.36	-	.0036	.0025	-	-	1.53	.0306	.0000	.06	4.8	.0023

Horn Pond.

Average of 14 samples collected in 1903.	.26	7.82	2.66	.0089	.0243	.0182	.0061	0.89	.0604	.0011	.45	3.0	-
Average of twelve previous years,	.29	8.51	2.33	.0068	.0333	.0210	.0123	1.36	.0507	.0010	.44	3.1	-

Water Supply of Worcester.

Bottomly Pond, on Kettle Brook, Paxton.

Average of 4 samples collected in 1903.	.58	3.90	1.70	.0096	.0244	.0183	.0061	0.22	.0115	.0000	.72	1.1	-

Kent Reservoir, on Kettle Brook, Leicester.

Average of 4 samples collected in 1903.	.34	3.50	1.46	.0036	.0182	.0153	.0029	0.20	.0075	.0001	.52	1.1	-

Lynde Brook Storage Reservoir.

Average of 12 samples collected in 1903.	.24	3.05	1.19	.0035	.0143	.0121	.0022	0.18	.0066	.0001	.40	0.7	-

Upper Reservoir on Tatnuck Brook.

Average of 12 samples collected in 1903.	.14	2.01	0.82	.0014	.0131	.0099	.0032	0.14	.0016	.0000	.30	0.3	-

Lower Reservoir on Tatnuck Brook.

Average of 12 samples collected in 1903.	.07	2.27	0.86	.0018	.0118	.0096	.0023	0.14	.0024	.0000	.22	0.4	-

WRENTHAM.

Water examined in Connection with Advice to the Town Authorities. (See also page 87.)

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1903.												
45829	June 16	None.	None.	.01	4.10	.0004	.0004	.34	.0400	.0000	.02	1.4	.0020

The sample was collected from a well at the Washington Park Hotel.

EXAMINATION OF RIVERS.

EXAMINATION OF RIVERS.

In the previous report (for the year 1902), in the chapter entitled "Report upon the Examinations of the Outlets of Sewers and the Effect of Sewage Disposal in Massachusetts," the results of the investigation of the sources of pollution of streams in the State made in that year are presented in much detail, together with the results of analyses of the waters of these streams for a long series of years.

During the year 1903 the condition of the various streams has been observed as usual, but the flow of streams during this year has been above the normal, especially in summer; and, as the temperature in the summer season was abnormally low, no material change in the condition of the various polluted streams has taken place since the previous year, and it has not been deemed necessary to present in detail the results of such examinations as have been made.

The monthly chemical analyses of samples of the waters of the Blackstone, Charles, Concord, Connecticut, Hoosick, Housatonic, Merrimack, Nashua, Neponset, Taunton and Westfield rivers have been continued during the year; the waters of several other streams were examined during the summer months, — among them the Assabet, Chicopee, Deerfield, French, Green, Manhan, Mill (Northampton), Miller's, Mumford, Quaboag, Quinebaug, Salisbury Plain, Seven Mile, Shawsheen, Ten Mile and Ware; and occasional examinations have been made of other streams.

A summary of the results of the examinations of some of the streams in the State is given on preceding pages, in connection with the examination of water supplies, as follows: —

	Page
Charles at Milford,	174
Green at Great Barrington,	157
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Merrimack at Lawrence,	164
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Saugus at Montrose,	168
Stillwater at Sterling,	138
Sudbury at Framingham,	140
Taunton at Bridgewater,	147

A summary of the various analyses, showing the condition of the Blackstone and Merrimack rivers at several points, is appended.

BLACKSTONE RIVER.

CHEMICAL EXAMINATION OF WATER FROM THE BLACKSTONE RIVER — AVERAGES FOR SIX MONTHS, FROM JUNE TO NOVEMBER, 1887 TO 1903, INCLUSIVE.

Blackstone River, between Mill Brook Channel and the Sewage Precipitation Works of the City of Worcester.

[Parts per 100,000.]

Months.	Color.	Residue on Evaporation.		Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Nitrogen as		Hardness.
		Total.	Loss on Ignition.		Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
June-Nov., 1887, . .	.91	-	-	.2686	.1741	-	-	1.35	.0160	-	-
" " 1888, . .	.76	-	-	.2658	.1112	.0557	.0555	1.50	.0382	.0041	-
" " 1889, . .	.86	-	-	.3980	.1430	.0772	.0658	1.32	.0177	.0026	-
" " 1890, . .	1.14	9.92	3.03	.2107	.1246	.0673	.0573	1.07	.0250	.0015	2.9
" " 1891, . .	1.10	17.42	5.59	.4913	.1950	.1127	.0823	2.29	.0192	.0037	5.0
" " 1892, . .	.52	20.75	6.30	.3547	.1433	.0708	.0725	2.43	.0227	.0108	6.1
" " 1893, . .	.40	16.98	4.55	.1480	.0588	.0240	.0348	1.01	.0115	.0015	6.3
" " 1894, . .	.66	16.93	4.76	.0548	.0380	.0236	.0144	.74	.0115	.0005	4.4
" " 1895, . .	.49	14.17	4.50	.0613	.0414	.0243	.0171	.92	.0163	.0006	3.4
" " 1896, . .	.51	12.90	2.93	.0780	.0415	.0282	.0133	.97	.0147	.0015	3.4
" " 1897, . .	.85	26.45	7.68	.1130	.0674	.0362	.0312	.89	.0090	.0024	4.2
" " 1898, . .	.33	17.42	5.62	.0857	.0619	.0260	.0359	.96	.0053	.0010	4.6
" " 1899, . .	.14	34.38	10.60	.2583	.0788	.0390	.0398	-	-	.0004	14.3
" " 1900, . .	.05	16.48	3.38	.1068	.0518	.0210	.0308	1.03	.0107	.0012	3.6
" " 1901, . .	.23	31.03	11.68	.1410	.0548	.0309	.0239	-	-	.0023	13.8
" " 1902, . .	.10	46.15	12.47	.2453	.0728	.0274	.0454	-	-	.0010	16.5
" " 1903, . .	.18	24.06	6.80	.2836	.0750	.0472	.0278	-	-	.0027	8.4

Blackstone River, below Sewage Precipitation Works.

June-Nov., 1887, . .	.91	-	-	.2686	.1741	-	-	1.35	.0160	-	-
" " 1888, . .	.76	-	-	.2658	.1112	.0557	.0555	1.50	.0382	.0041	-
" " 1889, . .	.86	-	-	.3980	.1430	.0772	.0658	1.32	.0177	.0026	-
" " 1890, . .	.97	11.36	3.10	.2907	.1492	.0722	.0770	1.46	.0270	.0018	3.9
" " 1891, . .	1.05	22.25	6.60	.6367	.1508	.0853	.0625	2.61	.0233	.0040	6.2
" " 1892, . .	.63	26.80	7.75	.5240	.1810	.0958	.0852	3.13	.0137	.0050	10.3
" " 1893, . .	.51	30.00	7.13	.5680	.1453	.0900	.0553	2.76	.0285	.0126	10.9
" " 1894, . .	.40	29.30	5.86	.6189	.1390	.1113	.0277	2.63	.0212	.0071	10.6
" " 1895, . .	.71	22.15	5.18	.3246	.0898	.0597	.0301	1.86	.0267	.0063	7.3
" " 1896, . .	.30	26.03	6.58	.2831	.0898	.0600	.0298	2.10	.0217	.0118	9.7
" " 1897, . .	.73	25.98	4.97	.3650	.1122	.0782	.0340	1.61	.0207	.0063	6.9
" " 1898, . .	.23	25.63	6.73	.3004	.0868	.0560	.0308	1.55	.0132	.0119	9.2
" " 1899, . .	.14	44.02	9.67	.5251	.1707	.0912	.0795	3.26	.0108	.0068	16.1
" " 1900, . .	.22	24.57	4.48	.4430	.1249	.0621	.0628	2.13	.0110	.0145	7.3
" " 1901, . .	.09	31.12	6.90	.4580	.1293	.0772	.0521	3.42	.0090	.0058	10.8
" " 1902, . .	.15	49.62	13.38	.7296	.1284	.0736	.0548	2.97	-	.0033	12.5
" " 1903, . .	.39	31.08	9.48	.3880	.1060	.0545	.0535	-	-	.0062	10.4

BLACKSTONE RIVER.

CHEMICAL EXAMINATION OF WATER FROM THE BLACKSTONE RIVER, ETC. — *Concluded.*

Blackstone River, at Uxbridge.

[Parts per 100,000.]

Months.	Color.	Residue on Evaporation.		Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Nitrogen as		Hardness.
		Total.	Loss on Ignition.		Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
June-Nov., 1887,	.39	-	-	.1129	.0271	-	-	.79	.0360	-	-
" " 1888,	.38	6.42	1.52	.1155	.0288	.0222	.0066	.68	.0310	.0007	-
" " 1889,	.32	-	-	.1133	.0296	.0192	.0104	.66	.0333	.0009	-
" " 1890,	.26	8.86	2.12	.1629	.0231	.0174	.0057	.79	.0259	.0005	2.9
" " 1891,	.20	10.16	2.61	.2280	.0175	.0117	.0058	1.04	.0425	.0007	3.6
" " 1892,	.13	9.36	1.88	.2840	.0227	.0162	.0065	.99	.0313	.0007	3.1
" " 1893,	.24	11.74	2.37	.1985	.0207	.0140	.0067	1.20	.0623	.0050	4.2
" " 1894,	.35	13.07	2.03	.1456	.0243	.0183	.0060	1.57	.0673	.0050	4.9
" " 1895,	.56	12.95	2.69	.0906	.0258	.0182	.0076	1.34	.0631	.0065	4.7
" " 1896,	.33	12.68	2.67	.1129	.0257	.0221	.0036	1.38	.0477	.0091	5.0
" " 1897,	.48	11.60	2.47	.1029	.0280	.0215	.0065	1.32	.0652	.0051	4.3
" " 1898,	.49	10.59	2.78	.0801	.0264	.0219	.0045	1.00	.0470	.0076	3.8
" " 1899,	.18	18.34	3.11	.2490	.0359	.0310	.0049	2.17	.0510	.0141	7.4
" " 1900,	.19	13.42	2.04	.2260	.0347	.0257	.0090	1.76	.0558	.0060	5.0
" " 1901,	.22	13.91	2.67	.3159	.0285	.0240	.0045	1.50	.0195	.0035	5.0
" " 1902,	.15	14.17	2.56	.3462	.0270	.0218	.0052	1.95	.0210	.0018	4.9
" " 1903,	.30	13.16	2.52	.3030	.0262	.0215	.0047	1.74	.0210	.0024	4.4

Blackstone River, at Millville.

June-Nov., 1887,	.31	-	-	.0468	.0220	-	-	.51	.0210	-	-
" " 1888,	.41	5.22	1.40	.0467	.0296	.0233	.0063	.50	.0278	.0004	-
" " 1889,	.38	-	-	.0499	.0273	.0213	.0060	.45	.0167	.0003	-
" " 1890,	.26	6.71	2.24	.0736	.0196	.0152	.0044	.53	.0229	.0003	2.3
" " 1891,	.24	7.48	2.35	.1105	.0384	.0234	.0150	.72	.0308	.0006	2.2
" " 1892,	.37	6.70	1.62	.1143	.0294	.0210	.0084	.63	.0217	.0002	2.0
" " 1893,	.23	7.43	1.73	.0677	.0119	.0087	.0032	.77	.0385	.0011	2.6
" " 1894,	.47	8.42	2.16	.0510	.0172	.0139	.0033	.89	.0273	.0012	2.8
" " 1895,	.51	8.67	2.55	.0356	.0233	.0180	.0053	.90	.0383	.0024	3.2
" " 1896,	.35	8.53	1.69	.0484	.0237	.0180	.0057	.97	.0413	.0027	3.3
" " 1897,	.45	7.66	1.98	.0509	.0258	.0210	.0048	.92	.0445	.0019	3.1
" " 1898,	.51	7.12	2.17	.0325	.0240	.0193	.0047	.63	.0240	.0023	2.5
" " 1899,	.20	12.50	2.44	.1310	.0301	.0247	.0054	1.31	.0310	.0049	4.6
" " 1900,	.29	9.33	1.82	.1168	.0254	.0219	.0035	1.15	.0417	.0039	3.4
" " 1901,	.31	8.62	2.13	.1420	.0288	.0227	.0061	.87	.0155	.0006	3.1
" " 1902,	.28	9.43	2.24	.1623	.0284	.0238	.0046	1.20	.0195	.0010	2.8
" " 1903,	.33	8.46	1.85	.1397	.0233	.0189	.0044	1.10	.0192	.0010	2.9

NOTE. — The sewage purification works of the city of Worcester were put in operation in 1890, since which time a portion of the sewage of the city has been treated. The works were enlarged in 1893, and since that time practically all of the dry-weather flow of sewage has been treated.

Merrimack River.

Table comparing the Analyses above Lowell with those above Lawrence, 1903.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.	
					Total.	Dissolved.	Suspended.				
Mean of analyses above Lowell, . . .	.29	3.65	1.42	.0045	.0159	.0123	.0036	.20	.0050	.0002	1.0
Mean of analyses above Lawrence, . .	.33	4.21	1.60	.0088	.0224	.0168	.0056	.27	.0064	.0004	1.2
Increase, ...	.04	0.56	0.18	.0043	.0065	.0045	.0020	.07	.0014	.0002	0.2

In order to compare these results with similar ones obtained in previous years, another table is presented, which shows the increase in impurities as the water passes from a point above Lowell to Lawrence, as given in the last line of the above table, and the corresponding increase in previous years.

Increase in the Amount of Impurities in the Merrimack River Water, from a Point above Lowell to Lawrence, as determined by the Regular Monthly Examinations of Different Years.

[Parts per 100,000.]

Date.	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.	
					Total.	Dissolved.	Suspended.				
Increase, 1887-1889, .	0.01	0.23	0.09	.0007	.0027	.0017	.0010	.026	.0003*	.0000	-
Increase, 1890, . .	0.05	0.62	0.22*	.0016	.0023	.0017	.0006	.028	.0020*	.0000	0.2
Increase, 1891, . .	0.02*	0.29	0.07	.0021	.0023	.0021	.0002	.035	.0030*	.0000	0.1
Increase, 1892, . .	0.06	0.48	0.12	.0019	.0087	.0037	.0000	.039	.0013*	.0000	0.0
Increase, 1893, . .	0.09	0.47	0.30	.0031	.0032	.0021	.0011	.035	.0002*	.0001	0.0
Increase, 1894, . .	0.02	0.15	0.04	.0028	.0032	.0032	.0000	.049	.0000	.0000	0.1
Increase, 1895, . .	0.11	0.52	0.33	.0022	.0063	.0046	.0017	.063	.0005	.0001	0.1
Increase, 1896, . .	0.02	0.51	0.24	.0034	.0053	.0047	.0006	.070	.0017	.0002	0.2
Increase, 1897, . .	0.06	0.30	0.08	.0019	.0051	.0033	.0018	.050	.0000	.0000	0.1
Increase, 1898, . .	0.03	0.37	0.07	.0024	.0039	.0019	.0020	.044	.0010	.0002	0.1
Increase, 1899, . .	0.02	0.39	0.07	.0038	.0045	.0023	.0022	.059	.0004*	.0001	0.1
Increase, 1900, . .	0.03	0.41	0.11	.0037	.0027	.0026	.0001	.055	.0011	.0000	0.0
Increase, 1901, . .	0.03	0.27	0.03	.0032	.0044	.0023	.0021	.053	.0020	.0003	0.3
Increase, 1902, . .	0.03	0.52	0.20	.0032	.0063	.0027	.0036	.060	.0000	.0001	0.1
Increase, 1903, . .	0.04	0.56	0.18	.0043	.0065	.0045	.0020	.072	.0014	.0002	0.2

The average flow of the river at Lawrence, for twenty-four hours, during the days on which samples were collected, was for the above periods, respectively, at the rate of 9,145, 9,948, 7,931, 5,434, 8,126, 5,459, 11,634, 5,886, 8,230, 9,402, 7,406, 7,389, 8,524, 9,160 and 9,674 cubic feet per second.

* Decrease.

SUMMARY

OF

WATER SUPPLY STATISTICS;

ALSO

RECORDS OF RAINFALL AND FLOW OF STREAMS.

SUMMARY OF WATER SUPPLY STATISTICS.

Public water supplies were introduced during the year 1903 into the towns of Deerfield, Shirley and Williamsburg, making the total number of cities and towns in the State provided with public water supplies 171.

The following table gives the classification by population of cities and towns having and not having public water supplies Dec. 31, 1903. The populations are taken from the census of 1900.

POPULATION (1900).	Number of Places of Given Population having a Public Water Supply.	Total Population of Places in Preceding Column.	Number of Places of Given Population not having a Public Water Supply.	Total Population of Places in Preceding Column.
Under 500,	0	0	37	13,383
500-999,	2	1,650	51	39,792
1,000-1,499,	11	13,994	36	43,435
1,500-1,999,	13	23,217	29	49,345
2,000-2,499,	11	24,429	13	29,003
2,500-2,999,	7	18,755	6	16,598
3,000-3,499,	10	32,018	3	10,020
3,500-3,999,	9	33,123	5	18,590
4,000-4,499,	7	29,878	1	4,364
4,500-4,999,	9	42,170	0	0
Above 5,000,	92	2,355,861	1	5,721
Totals,	171	2,575,095	182	230,251

From the totals given in the table it will be seen that, although but 48.4 per cent. of the total number of cities and towns in the State have a public water supply, yet the total population of places supplied represents 91.8 per cent. of the whole population of the State. In this estimate of the total population of municipalities supplied all of the inhabitants are included, and it consequently includes rather more than the actual number of persons to whom a public water supply is available. The difference, however, is not large.

There are now 10 towns, having by the census of 1900 a population exceeding 3,000, which are not provided with public water supplies. These are given in the following table: —

Town.	Population in 1900.	Town.	Population in 1900.
Blackstone,	5,721	Dartmouth,	3,669
Barnstable,	4,364	Dudley,	3,553
Chelmsford,	3,984	Templeton,	3,489
Pepperell,	3,701	Sutton,	3,328
Tewksbury,	3,683	Hardwick,	3,203

The 3 water supplies which were introduced during the year 1903 are owned by the town or by a fire district, and during the year the works of the Wakefield Water Company were taken by the town of Wakefield, making an increase of 4 in the number of towns owning their works.

Of the 171 cities and towns having public water supplies at the end of the year 1903, all of the cities and 91 of the towns own their water works, while but 47 towns are wholly supplied by private companies.

The following table gives the classification by population of the towns which own their water works and those which are supplied with water by private companies: —

Population (1900).	Number of Places of Given Population owning Water Works.	Total Population of Places in Preceding Column.	Number of Places of Given Population supplied with Water by Private Companies.	Total Population of Places in Preceding Column.
Under 1,000,	2	1,650	0	0
1,000-1,999,	12	18,397	12	18,814
2,000-2,999,	9	21,600	9	21,584
3,000-3,999,	12	41,726	7	23,415
4,000-4,999,	13	58,302	3	13,746
5,000-5,999,	13	70,870	5	25,923
6,000-6,999,	6	38,778	1	6,058
7,000-7,999,	7	52,254	4	29,355
Above 8,000,	50	2,066,808	6	65,815
Totals,	124	2,370,385	47	204,710

It will be seen by the totals given in the table that the population of those towns supplied with water by private companies is only 8 per cent. of the total population in all of the cities and towns supplied with water, and that there are now only 6 towns having a population above 8,000 which are supplied by private companies.

Records of the consumption of water are kept in nearly all cities and towns where water is pumped. A summary of these statistics for the year 1903 is given in the following table. The estimated population given in the table is obtained by adding three-fifths of the increase in population from 1895 to 1900 to the population as determined by the census taken in the latter year. The daily consumption of water per inhabitant has been obtained by dividing the average daily consumption by the estimated population of the city or town in 1903. The quantity obtained in this manner varies somewhat from the actual consumption per person using the water,

as in many cities and towns there is a considerable number of people who do not use the public water supply, while in some of the towns used as summer resorts the population using the water during the summer months is much greater than the population shown by the census. With a few exceptions, however, the error is not large.

Statistics relating to the Consumption of Water in Various Cities and Towns.

City or Town.	Estimated Population in 1903.	Average Daily Consumption (Gallons), 1903.	Daily Consumption per Inhabitant (Gallons), 1903.	City or Town.	Estimated Population in 1903.	Average Daily Consumption (Gallons), 1903.	Daily Consumption per Inhabitant (Gallons), 1903.
Metropolitan Water District.	900,500	107,148,000	119	Lawrence,	68,796	2,838,000	41
Abington and Rockland.	9,867	405,000	41	Lincoln,	1,136	177,000	156
Andover,	7,215	364,000	50	Lowell,	101,329	5,267,000	52
Attleborough,	13,163	466,000	35	Lynn and Saugus,	77,644	5,138,000	66
Avon,	1,810	65,000	36	Manchester,	2,909	299,000	103
Ayer,	2,653	93,000	35	Mansfield,	4,177	189,000	45
Beverly,	15,132	1,111,000	73	Marblehead,	7,528	559,000	74
Billerica,	2,894	80,000	28	Marlborough,	12,787	570,000	45
Braintree,	6,383	574,000	90	Maynard,	3,172	340,000	107
Bridgewater and East Bridgewater.	9,581	185,000	19	Methuen,	8,604	302,000	35
Brockton,	44,203	1,473,000	33	Middleborough,	7,002	248,000	35
Brookline,	22,197	2,116,000	95	Milford and Hopedale.	15,338	810,000	53
Cambridge,	98,032	8,642,000	88	Millbury,	4,003	207,000	52
Canton,	4,553	254,000	56	Montague,	6,204	572,000	91
Danvers and Middleton.	9,598	721,000	75	Nantucket,	3,000	143,000	48
Dedham,	8,151	796,000	98	Natick,	9,893	491,000	50
Easton,	5,068	141,000	28	Needham,	4,319	295,000	68
Fairhaven,	3,705	354,000	96	New Bedford,	66,756	6,946,000	104
Fall River,	114,259	4,278,000	37	Newburyport,	14,433	707,000	49
Falmouth,	4,007	181,000	45	Newton,	37,184	2,110,000	57
Foxborough,	3,296	176,000	54	North Andover,	4,648	111,000	24
Framingham,	12,376	524,000	42	North Attleborough,	7,658	236,000	31
Franklin,	4,945	223,000	45	North Brookfield,	4,557	185,000	41
Gardner,	11,791	973,000	83	Norwood,	6,023	394,000	65
Gloucester,	24,867	1,102,000	44	Orange,	5,616	146,000	26
Grafton,	4,731	87,000	18	Peabody,	12,133	1,492,000	123
Groton,	1,968	66,000	34	Provincetown,	4,062	142,000	35
Holliston,	2,526	27,000	11	Randolph and Holbrook.	6,360	233,000	37
Hyde Park,	14,096	1,020,000	72	Reading,	5,119	146,000	28
Ipswich,	4,622	132,000	29	Rockport,	4,175	275,000	66

Statistics relating to the Consumption of Water in Various Cities and Towns — Concluded.

City or Town.	Estimated Population in 1903.	Average Daily Consumption (Gallons), 1903.	Daily Consumption per Inhabitant (Gallons), 1903.	City or Town.	Estimated Population in 1903.	Average Daily Consumption (Gallons), 1903.	Daily Consumption per Inhabitant (Gallons), 1903.
Salem,	36,847	3,175,000	86	Ware,	8,629	328,000	38
Scituate,	2,605	68,000	26	Wareham, Onset Bay.	3,471	33,000	10
Sharon,	2,267	74,000	33	Webster,	8,807	269,000	31
Stoughton,	5,544	283,000	51	Wellesley,	5,579	294,000	53
Taunton,	33,388	1,531,000	46	Weston,	1,909	65,000	34
Tisbury,	1,236	79,000	64	Whitman,	6,401	131,000	21
Wakefield,	9,881	588,000	60	Winchendon,	5,307	114,000	21
Walpole,	3,920	273,000	70	Woburn,	14,299	1,378,000	96
Waltham,	25,044	2,254,000	90	Worcester,	130,214	9,688,000	74

Rainfall.

The average rainfall in Massachusetts, as deduced from long-continued observations in various parts of the State, is 45.53 inches. The average rainfall for the year 1903 in these places was 45.26 inches, making a deficiency of 0.27 of an inch. The greatest excess in any one month in 1903 occurred in June, when the rainfall was 7.75 inches. There was also an excess in the months of February, March, April and August. The greatest deficiency occurred in the months of May, September and November.

The following table gives the normal rainfall in the State for each month, as deduced from the observations at various places for a long period of years, together with the average rainfall at those places for each month during 1903, and the departures from the normal: —

Month.	Normal Rainfall. Inches.	Rainfall. 1903. Inches.	Excess or Deficiency. 1903. Inches.	Month.	Normal Rainfall. Inches.	Rainfall. 1903. Inches.	Excess or Deficiency. 1903. Inches.
January,	3.87	3.65	−0.22	August,	4.28	4.46	+0.18
February,	3.79	4.18	+0.39	September,	3.34	1.94	−1.40
March,	4.18	6.31	+2.13	October,	4.06	3.83	−0.23
April,	3.49	3.78	+0.29	November,	4.03	2.04	−1.99
May,	3.68	0.67	−3.01	December,	3.70	3.15	−0.55
June,	3.28	7.75	+4.47	Total,	45.53	45.26	−0.27
July,	3.83	3.50	−0.33				

Flow of Streams.

The flow of streams for the year 1903, as indicated by the records of the Sudbury River, was somewhat above the normal. The flow was in excess of the normal during each month from January to August inclusive, with the exception of May, and was less than the normal during the remaining four months of the year. The greatest excess occurred in June and the greatest deficiency in May.

In order to show the relation between the flow of the Sudbury River during each month of 1903 and the normal flow as deduced from observations during the twenty-nine years from 1875 to 1903, inclusive, the following table has been prepared. The area of the water-shed of the Sudbury River above the point of measurement is 75.2 square miles.

Table showing the Average Monthly Flow of Sudbury River for the Year 1903 in Cubic Feet per Second per Square Mile of Drainage Area and in Gallons per Day per Square Mile of Drainage Area, also Departures from the Normal Flow.

Month.	Normal Flow.		Actual Flow for 1903.		Excess or Deficiency.	
	Cubic Feet per Second per Square Mile.	Million Gallons per Day per Square Mile.	Cubic Feet per Second per Square Mile.	Million Gallons per Day per Square Mile.	Cubic Feet per Second per Square Mile.	Million Gallons per Day per Square Mile.
January,	1.922	1.242	2.685	1.736	+0.763	+0.494
February,	2.933	1.896	3.526	2.279	+0.593	+0.383
March,	4.620	2.987	5.344	3.454	+0.724	+0.467
April,	3.212	2.076	3.498	2.261	+0.286	+0.185
May,	1.734	1.121	0.542	0.351	−1.192	−0.770
June,	0.813	0.526	3.075	1.987	+2.262	+1.461
July,	0.306	0.198	0.689	0.445	+0.383	+0.247
August,	0.456	0.295	0.475	0.307	+0.019	+0.012
September,	0.360	0.233	0.201	0.130	−0.159	−0.103
October,	0.800	0.517	0.761	0.492	−0.039	−0.025
November,	1.375	0.889	0.561	0.363	−0.814	−0.526
December,	1.718	1.111	0.901	0.582	−0.817	−0.529
	1.680	1.086	1.841	1.190	+0.161	+0.104

The next table shows the weekly fluctuations during 1903 in the flow of three streams which were carefully measured, namely, the Sudbury, the south branch of the Nashua, and the Merrimack. The flow of these streams, particularly the Sudbury and the south branch of the Nashua, serves to indicate the flow of other streams in eastern Massachusetts.

The flow of the Merrimack River is affected to some extent by the diversion of water from two of its tributaries for the water supply of the

Metropolitan District. The quantity diverted in 1903 amounted to about 165 cubic feet per second, which would reduce the figures given for the flow per square mile of water-shed about 0.035 of a cubic foot per second.

The water-shed of the Sudbury River is 75.2 square miles, of the Nashua 119 square miles, and of the Merrimack 4,664 square miles.

Week ending Sunday.	Flow in Cubic Feet per Second per Square Mile of Water-shed.			Week ending Sunday.	Flow in Cubic Feet per Second per Square Mile of Water-shed.		
	Sudbury River.	South Branch Nashua River.	Merrimack River.		Sudbury River.	South Branch Nashua River.	Merrimack River.
1903.				**1903.**			
Jan. 4,	3.191	2.656	1.876	July 5,	1.679	1.580	1.557
11,	2.902	2.100	1.979	12,	0.617	0.780	0.865
18,	1.855	1.385	1.436	19,	0.170	0.783	0.675
25,	2.787	1.886	1.545	26,	1.099	1.090	1.247
Feb. 1,	2.815	2.157	1.602	Aug. 2,	0.056	0.882	0.853
8,	3.956	3.853	2.249	9,	1.218	1.225	0.801
15,	4.159	3.746	2.238	16,	0.418	0.660	0.735
22,	2.103	1.992	1.867	23,	0.210	0.434	0.626
Mar. 1,	4.501	4.804	2.174	30,	0.346	0.622	0.673
8,	3.304	4.005	4.547	Sept. 6,	0.490	0.711	0.617
15,	6.334	7.291	7.766	13,	0.297	0.456	0.511
22,	3.319	3.037	5.220	20,	0.121	0.672	0.480
29,	7.774	5.881	6.697	27,	0.084	0.517	0.471
Apr. 5,	5.328	4.722	4.692	Oct. 4,	0.004	0.482	0.447
12,	5.048	4.899	4.211	11,	0.402	1.161	0.531
19,	3.755	3.880	3.419	18,	1.701	1.513	1.101
26,	1.990	2.151	2.326	25,	0.942	1.062	1.020
May 3,	0.918	1.452	1.513	Nov. 1,	0.297	0.815	0.699
10,	1.028	1.333	1.245	8,	0.286	0.703	0.622
17,	0.474	0.937	0.984	15,	0.470	0.630	0.593
24,	0.436	0.635	0.773	22,	0.691	1.751	0.772
31,	0.290	0.452	0.532	29,	0.614	0.895	0.595
June 7,	0.081	0.432	0.391	Dec. 6,	0.981	0.690	0.520
14,	1.903	2.158	0.929	13,	0.894	1.600	0.565
21,	5.552	6.013	2.819	20,	−0.022	1.816	0.740
28,	5.049	4.889	4.740	27,	1.643	1.967	1.368

The following table gives the rainfall upon the Sudbury River water-shed and its total yield expressed in inches in depth on the water-shed (inches of rainfall collected) for the year 1903, together with the average of the records of twenty-nine years, from 1875 to 1903 inclusive: —

Rainfall, in Inches, received and collected on Sudbury Watershed.

Month.	1903.			Mean for 29 Years, 1875-1903.		
	Rainfall.	Rainfall collected.	Per Cent. collected.	Rainfall.	Rainfall collected.	Per Cent. collected.
January,	3.80	3.096	81.4	4.18	2.216	53.0
February,	3.95	3.672	93.0	4.39	3.076	70.2
March,	6.63	6.161	92.9	4.66	5.326	114.4
April,	2.99	3.903	130.5	3.43	3.582	104.6
May,	0.93	0.625	67.4	3.37	1.999	59.4
June,	9.25	3.431	37.1	3.10	0.907	29.3
July,	2.77	0.794	28.7	3.73	0.353	9.5
August,	3.67	0.547	14.9	4.06	0.526	13.0
September,	1.75	0.225	12.8	3.23	0.402	12.4
October,	4.72	0.877	18.6	4.31	0.922	21.4
November,	1.56	0.626	40.2	4.03	1.534	38.0
December,	3.14	1.038	33.1	3.85	1.981	51.5
Totals and averages,	45.16	24.995	55.4	46.34	22.824	49.3

The Sudbury River records are particularly valuable as a basis for estimating the yield of other water-sheds in Massachusetts, both on account of the accuracy with which the measurements have been made, and the absence of abnormal conditions which would unfavorably affect the results.

The following table gives the records of the yield of this water-shed for each of the past twenty-nine years, the flow from the water-shed being expressed in gallons per day per square mile of water-shed, in order to render the table more convenient for use in estimating the probable yield of water-sheds used as sources of water supply.

*Yield of the Sudbury River Water-shed in Gallons per Day per Square Mile.**

MONTH.	1875.	1876.	1877.	1878.	1879.	1880.	1881.
January,	103,000	643,000	658,000	1,810,000	700,000	1,121,000	415,000
February,	1,496,000	1,368,000	949,000	2,465,000	1,711,000	1,787,000	1,546,000
March,	1,604,000	4,435,000	4,813,000	3,507,000	2,330,000	1,374,000	4,004,000
April,	3,049,000	3,292,000	2,394,000	1,626,000	3,116,000	1,168,000	1,546,000
May,	1,188,000	1,139,000	1,391,000	1,394,000	1,114,000	514,000	965,000
June,	870,000	222,000	597,000	506,000	413,000	176,000	1,338,000
July,	321,000	183,000	202,000	128,000	158,000	177,000	276,000
August,	396,000	405,000	121,000	475,000	395,000	119,000	148,000
September,	207,000	184,000	60,000	160,000	141,000	80,000	197,000
October,	646,000	234,000	632,000	516,000	71,000	101,000	186,000
November,	1,302,000	1,088,000	1,418,000	1,693,000	206,000	205,000	395,000
December,	584,000	454,000	1,289,000	3,177,000	462,000	175,000	775,000
Av. for whole year,	972,000	1,135,000	1,214,000	1,452,000	894,000	578,000	979,000
Av. for driest six months,	574,000	384,000	502,000	532,000	230,000	143,000	330,000

MONTH.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
January,	1,241,000	335,000	995,000	1,235,000	1,461,000	2,589,000	1,053,000
February,	2,403,000	1,033,000	2,842,000	1,354,000	4,800,000	2,829,000	1,951,000
March,	2,839,000	1,611,000	3,785,000	1,572,000	2,059,000	2,868,000	3,237,000
April,	867,000	1,350,000	2,853,000	1,815,000	1,947,000	2,620,000	2,645,000
May,	1,292,000	938,000	1,030,000	1,336,000	720,000	1,009,000	1,632,000
June,	529,000	300,000	417,000	426,000	203,000	414,000	422,000
July,	86,000	115,000	224,000	62,000	115,000	114,000	117,000
August,	55,000	78,000	257,000	240,000	94,000	214,000	380,000
September,	306,000	91,000	44,000	121,000	118,000	111,000	1,155,000
October,	299,000	186,000	83,000	336,000	146,000	190,000	1,999,000
November,	210,000	205,000	175,000	1,178,000	673,000	368,000	2,758,000
December,	314,000	193,000	925,000	1,174,000	1,020,000	643,000	3,043,000
Av. for whole year,	862,000	533,000	1,129,000	901,000	1,087,000	1,154,000	1,697,000
Av. for driest six months,	211,000	145,000	200,000	391,000	223,000	234,000	953,000

* The area of the Sudbury River water-shed used in making up these records included water surfaces amounting to about [illegible] per cent. of the whole area, from 1875 to 187[illegible] inclusive, subsequently increasing by the construction of storage reservoirs to about 3 per cent. in 1879, to 3.[illegible] per cent. in 1885, to 4 per cent. in [illegible]894 and to [illegible].5 per cent. in 1898. The water-shed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.

Yield of the Sudbury River Water-shed in Gallons per Day per Square Mile — Concluded.

Month.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.
January,	2,782,000	1,254,000	3,018,000	1,870,000	433,000	693,000	1,034,000	1,034,000
February,	1,195,000	1,529,000	3,486,000	943,000	1,542,000	991,000	541,000	2,676,000
March,	1,339,000	3,643,000	4,453,000	1,955,000	3,245,000	2,238,000	2,410,000	3,835,000
April,	1,410,000	1,875,000	2,397,000	871,000	2,125,000	1,640,000	2,515,000	1,494,000
May,	880,000	1,366,000	582,000	1,259,000	2,883,000	840,000	686,000	360,000
June,	653,000	568,000	414,000	428,000	440,000	419,000	174,000	399,000
July,	633,000	108,000	149,000	214,000	158,000	161,000	231,000	95,000
August,	1,432,000	132,000	163,000	280,000	181,000	209,000	229,000	57,000
September,	824,000	458,000	203,000	229,000	106,000	150,000	89,000	388,000
October,	1,230,000	2,272,000	210,000	126,000	221,000	374,000	1,379,000	592,000
November,	1,941,000	1,215,000	305,000	697,000	319,000	836,000	2,777,000	659,000
December,	2,241,000	997,000	544,000	485,000	797,000	716,000	1,782,000	657,000
Av. for whole year,	1,383,000	1,285,000	1,315,000	781,000	1,037,000	770,000	1,152,000	1,019,000
Av. for driest six months,	944,000	747,000	239,000	327,000	237,000	356,000	460,000	314,000

Month.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	Mean for 29 Years, 1875 to 1903, inclusive.
January,	845,000	1,638,000	2,288,000	794,000	437,000	1,763,000	1,786,000	1,242,000
February,	1,067,000	3,022,000	1,381,000	3,800,000	300,000	1,674,000	2,279,000	1,896,000
March,	2,565,000	2,604,000	4,205,000	3,654,000	2,755,000	4,199,000	3,454,000	2,987,000
April,	1,515,000	1,829,000	2,521,000	1,350,000	4,204,000	1,885,000	2,261,000	2,076,000
May,	915,000	1,246,000	511,000	1,312,000	2,954,000	743,000	351,000	1,121,000
June,	962,000	530,000	66,000	316,000	753,000	303,000	1,987,000	526,000
July,	658,000	231,000	19,000	—18,000	306,000	66,000	445,000	198,000
August,	591,000	1,107,000	—35,000	—34,000	424,000	135,000	307,000	295,000
September,	182,000	369,000	94,000	65,000	205,000	178,000	130,000	233,000
October,	94,000	1,160,000	115,000	186,000	412,000	506,000	492,000	517,000
November,	909,000	1,986,000	304,000	663,000	474,000	444,000	363,000	889,000
December,	1,584,000	1,799,000	220,000	1,096,000	2,695,000	1,779,000	582,000	1,111,000
Av. for whole year,	991,000	1,450,000	973,000	1,082,000	1,342,000	1,140,000	1,190,000	1,086,000
Av. for driest six months,	564,000	777,000	93,000	194,000	445,000	271,000	386,000	443,000

EXPERIMENTS

UPON THE

PURIFICATION OF SEWAGE AND WATER

AT THE

LAWRENCE EXPERIMENT STATION,

DURING THE YEAR 1903.

EXPERIMENTS UPON THE PURIFICATION OF SEWAGE AND WATER AT THE LAWRENCE EXPERIMENT STATION.*

By H. W. CLARK, *Chemist of the Board.*

During the year 1903 the following investigations upon the purification of sewage have been carried on at the Lawrence Experiment Station: —

1. Continuation of the older intermittent sand filters, with studies in regard to the cause of the lower winter nitrification in these filters during recent years, and methods of rejuvenating them.

2. Studies of septic tanks. In this work three tanks have been in operation: (1) a tank receiving regular station sewage, with a normal period of passage of this sewage through the tank, that is, twenty-four hours or less; (2) a tank through which the sewage is five days in passing, with studies of the character of the sewage after each day's stay in the tank, and studies of the operation of sand filters receiving the septic sewage drawn from different portions of the tank representative of each day's stay in the tank; (3) a tank receiving a sewage containing a large amount of mineral salts, causing the sewage to resemble that from a municipality with an exceedingly hard water supply, this study being undertaken in order to learn whether a considerable chemical precipitation did or did not occur in this sewage owing to the passing out of solution of these salts as the sewage changes in character in the tank. This experiment has been especially interesting as indicating a cause for the difference in degree of odor of sewage from different septic tanks.

3. Continuation of the operation of contact filters constructed of different materials and of different depths, with special regard to their permanency of operation, together with allied studies upon the stability or non-putrefactive quality of their effluents, etc.

4. Studies of intermittent continuous filtration through filters constructed of different materials and of different depths, together with laboratory investigations in regard to the stability of the effluents of these filters and experiments upon sedimentation, secondary filtration, etc., of these effluents.

5. Studies of the purification of dye liquors, gas wastes, etc.

6. Studies of methods of analysis with special regard to the comparative value of albuminoid ammonia and Kjeldahl determinations of nitrogen; of

* The work has been carried on under the general supervision of Hiram F. Mills, A.M., C.E., member of the State Board of Health, with the writer in direct charge. A full account of the work done at the Lawrence Experiment Station for the years 1888 and 1889 is contained in a special report of the State Board of Health upon the purification of sewage and water, 1890. A similar account for the years 1890 and 1891 is contained in the twenty-third annual report of the Board for 1891. Since 1891 the results have been published yearly in the annual reports.

incubation of effluents; of the nitrification and denitrification caused by sands, effluents and species of bacteria from filters in which either nitrification or reducing actions are occurring.

ANALYSES OF SEWAGE.

The sewage used at the station comes through a 2½-inch pipe about 4,400 feet long. The coarser matters of the sewage are disintegrated during the passage of the sewage through this pipe, but the sewage as received at the station is fully as strong and has nearly as much matter in suspension as the average sewage of the State flowing upon the municipal sand filter areas.

Determinations of the solid matter in this sewage have been made throughout the year, as during the year 1902, and the results are as follows: —

Average Solids in Station Sewage.

[Parts per 100,000.]

1903.	Unfiltered.			Filtered.			In Suspension.		
	Total.	Loss on Ignition.	Fixed.	Total.	Loss on Ignition	Fixed	Total.	Loss on Ignition.	Fixed.
January,	54.6	25.3	29.3	35.2	13.8	21.4	19.4	11.5	7.9
February,	50.1	28.6	21.5	33.9	15.6	18.3	16.2	13.0	3.2
March,	54.3	25.9	28.4	34.3	13.8	20.5	20.0	12.1	7.9
April,	64.5	32.4	32.1	44.5	16.1	28.4	20.0	16.3	3.7
May,	62.5	29.1	33.4	43.7	15.3	28.4	18.8	13.8	5.0
June,	66.3	27.8	38.5	49.6	18.9	30.7	16.7	8.9	7.8
July,	74.8	32.3	42.5	52.0	15.6	36.4	22.8	16.7	6.1
August,	70.2	31.9	38.3	52.8	18.9	33.9	17.4	13.0	4.4
September,	77.2	32.3	44.9	63.8	21.3	42.5	13.4	11.0	2.4
October,	84.7	37.3	47.4	57.0	20.8	36.2	27.7	16.5	11.2
November,	72.0	35.8	36.2	48.7	17.4	31.3	23.3	18.4	4.9
December,	62.5	28.9	33.6	50.4	20.9	29.5	12.1	8.0	4.1
Average,	66.1	30.6	35.5	47.2	17.4	29.8	18.9	13.2	5.7

The four following tables present the results of the usual analyses of the various samples of sewage collected during the year, — "Lawrence Street sewage" being the average of samples collected weekly from the sewer from which the sewage is pumped to the station; "regular station sewage" being the average of samples collected at the experiment station on at least four days each week; "sewage applied to Filters Nos. 1, 6 and 9 A" being the average of samples collected from all sewage applied to these filters; and "average sewage" being the average of all sewage pumped on each Tuesday of the year.

The different character of the sewage taken directly from the sewer and that pumped at the station is shown clearly by these analyses. The high albuminoid ammonia with lower free ammonia and high oxygen consumed, such as is shown by the analyses of the Lawrence Street sewage, is characteristic of fresh sewage, while the high free ammonia and lower albuminoid ammonia and oxygen consumed is characteristic of a stale sewage, as pumped at the station. A comparison of these tables, however, shows that the sewage used at the station contains fully as much nitrogen as the samples of sewage taken directly from the sewer.

Lawrence Street Sewage.

[Parts per 100,000.]

1903.	Temperature (Deg. F.).	Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Free.	Albuminoid.			Nitrates.	Nitrites.		
			Total.	In Solution.					
January,	52	2.59	.78	.50	11.90	.212	.0145	7.73	1,550,000
February,	46	1.89	.67	.42	7.71	.147	.0049	8.57	1,395,000
March,	50	1.70	.79	.36	6.81	.215	.0098	10.57	1,838,000
April,	51	1.50	.49	.33	7.26	.230	.0107	5.96	1,190,000
May,	61	2.24	.73	.47	10.65	.219	.0215	7.41	1,618,000
June,	63	2.36	.70	.44	12.75	.169	.0180	7.74	1,382,500
July,	67	1.97	.68	.45	12.52	.120	.0196	6.93	1,962,000
August,	70	2.39	.73	.43	13.87	.076	.0220	8.65	2,575,000
September,	70	2.25	.72	.45	12.55	.064	.0140	7.91	2,975,000
October,	64	2.29	.76	.46	19.63	.074	.0136	8.32	1,697,500
November,	61	2.40	.80	.51	10.29	.130	.0110	10.91	2,363,000
December,	56	2.24	.81	.50	8.59	.098	.0105	10.17	1,278,000
Average,	59	2.15	.72	.44	11.21	.146	.0142	8.41	1,819,000

Regular Station Sewage.

[Parts per 100,000.]

1903.	Temperature (Deg. F.).	Ammonia.			Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Free.	Albuminoid.				
			Total.	In Solution.			
January,	45	3.86	.59	.30	7.89	3.66	2,403,100
February,	47	3.78	.55	.30	7.56	3.77	2,158,000
March,	48	3.85	.56	.28	6.78	3.63	1,949,400
April,	52	4.55	.58	.30	7.91	3.50	1,629,300
May,	62	4.54	.56	.28	10.36	3.47	1,748,000
June,	63	4.23	.49	.27	10.97	3.46	2,059,100
July,	70	4.77	.57	.34	12.67	3.57	5,747,000
August,	67	4.21	.57	.27	11.48	3.86	2,384,700
September,	67	4.75	.58	.27	13.91	3.53	2,657,000
October,	56	4.98	.70	.29	12.50	5.07	2,758,000
November,	52	4.59	.67	.30	10.59	5.35	2,551,000
December,	52	4.53	.67	.35	8.87	4.90	2,514,700
Average,	57	4.39	.59	.30	10.12	3.98	2,546,600

Sewage applied to Filters Nos. 1, 6, and 9 A.

[Parts per 100,000.]

1903.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Oxygen Consumed.
January,	3.44	.56	7.98	4.18
February,	3.20	.54	7.71	4.44
March,	3.34	.49	7.22	3.86
April,	3.67	.59	8.48	3.87
May,	4.55	.67	11.10	4.12
June,	4.63	.57	12.21	3.93
July,	4.20	.61	13.50	4.17
August,	4.52	.58	13.14	4.11
September,	4.90	.63	14.16	3.94
October,	4.73	.62	14.56	5.07
November,	5.98	.80	13.19	5.97
December,	5.10	.71	10.82	5.55
Average,	4.36	.61	11.17	4.48

Average Sewage.

[Parts per 100,000.]

1903.	Temperature (Deg. F.).	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. In Solution.	Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January,	45	3.78	.67	.32	7.50	3.85	1,780,000
February,	45	4.23	.62	.31	9.84	3.89	1,610,000
March,	47	3.66	.52	.25	7.37	3.61	2,428,000
April,	53	4.93	.55	.26	8.66	3.64	1,180,000
May,	58	3.58	.48	.17	9.99	3.11	1,147,000
June,	65	3.55	.40	.28	8.92	3.32	1,482,500
July,	73	4.40	.54	.31	16.13	3.62	19,370,000
August,	67	3.85	.57	.26	14.45	3.93	2,357,500
September,	69	4.56	.50	.26	16.86	3.33	2,540,000
October,	56	4.10	.58	.25	15.55	5.31	2,755,000
November,	52	5.45	.78	.37	10.66	5.65	2,858,000
December,	52	4.68	.75	.36	10.14	4.85	3,236,000
Average,	57	4.23	.58	.28	11.34	4.01	3,562,000

Total Organic Nitrogen in Sewage.

In all, about two hundred and fifty Kjeldahl determinations have been made in the station laboratory during the year, and confirm the statements already made in regard to the amount of nitrogen present in the Lawrence Street sewage and the regular station sewage. Kjeldahl results have been as shown in the following tables, and in these tables are also given the average albuminoid ammonia results on all the samples of sewage examined by the Kjeldahl method, including the station sewage entering the various septic tanks in operation at the station, the effluents of these tanks and also the effluent of one of the intermittent continuous filters (No. 196) in operation at the station. It will be noticed that the fresh sewage from the sewer yields but 25 per cent. of its nitrogen by the albuminoid ammonia determination, while the remaining sewages yield from 25 to 42 per cent.

Lawrence Street Sewage.

[Parts per 100,000.]

1903.	Free Ammonia.	Albuminoid Nitrogen.	Kjeldahl Nitrogen.	Per Cent. which Nitrogen as Albuminoid Ammonia is of Organic Nitrogen.
April,	1.75	.46	1.95	23.5
May,	2.24	.59	2.33	25.3
June,	2.36	.58	2.67	21.7
July,	1.97	.56	1.97	28.4
August,	2.39	.59	2.33	25.3
September,	2.25	.59	2.17	27.2
October,	2.29	.62	2.11	29.4
November,	2.32	.60	2.39	25.1
December,	2.24	.67	3.16	21.2
Average,	-	-	-	25.6

Average Sewage for Filters Nos. 1, 6 and 9 A.

April,	3.90	.40	1.37	29.2
May,	4.55	.54	1.53	35.3
June,	4.62	.47	1.23	38.2
July,	4.20	.50	1.23	40.6
August,	4.52	.47	1.27	37.0
September,	4.90	.51	1.11	46.0
October,	4.90	.54	1.32	40.9
November,	5.98	.66	1.61	41.0
December,	5.10	.58	1.29	45.0
Average,	-	-	-	39.7

Sewage entering Septic Tank A.

[Parts per 100,000.]

1903.	Free Ammonia.	Albuminoid Nitrogen.	Kjeldahl Nitrogen.	Per Cent. which Nitrogen as Albuminoid Ammonia is of Organic Nitrogen.
April,	3.70	.38	1.29	29.5
May,	3.92	.42	1.03	40.8
June,	3.42	.33	0.92	35.8
July,	3.92	.42	1.19	35.3
August,	3.86	.49	1.24	39.5
September,	3.90	.43	1.12	38.4
October,	3.95	.53	1.40	37.8
November,	5.24	.62	1.41	44.0
December,	5.47	.44	1.17	37.6
Average,	-	-	-	38.0

Effluent of Septic Tank A.

April,	4.00	.23	0.74	31.1
May,	4.30	.23	0.68	33.8
June,	3.45	.26	0.63	41.2
July,	4.14	.28	0.64	43.7
August,	4.15	.31	0.79	39.2
September,	3.75	.29	0.78	37.1
October,	4.45	.33	0.87	37.9
November,	4.97	.39	0.92	42.4
December,	4.52	.39	0.94	41.5
Average,	-	-	-	39.1

Sewage entering Septic Tank E.

April,	4.20	.40	1.21	33.0
May,	4.37	.45	1.26	35.7
June,	4.27	.44	1.23	35.8
July,	3.98	.39	0.99	39.4
August,	3.95	.46	1.13	40.7
September,	3.15	.50	1.29	38.7
October,	4.63	.45	1.37	32.8
Average,	-	-	-	35.7

Effluent of Septic Tank E.

[Parts per 100,000.]

1903.	Free Ammonia.	Albuminoid Nitrogen.	Kjeldahl Nitrogen.	Per Cent which Nitrogen as Albuminoid Ammonia is of Organic Nitrogen.
April,	3.18	.23	0.76	30.2
May,	3.50	.21	0.56	37.4
June,	3.83	.22	0.61	36.0
July,	4.22	.23	0.60	38.4
August,	4.22	.25	0.58	43.1
September,	4.50	.24	0.57	42.0
October,	4.70	.30	0.75	40.0
Average,	-	-	-	38.2

Andover Sewage for Filter No. 222.

May,	3.60	.47	1.22	38.5
September,	6.20	.53	1.41	37.6
October,	6.33	.67	1.60	41.8
November,	7.32	.89	1.83	48.5
December,	3.19	.42	1.22	34.4
Average,	-	-	-	41.0

Sewage entering Septic Tank D.

April,	4.35	.45	1.87	24.0
May,	4.10	.43	1.00	43.0
June,	3.65	.24	0.75	32.0
July,	3.65	.46	1.31	35.1
August,	2.70	.29	1.00	29.0
September,	4.80	.36	1.02	35.3
October,	4.90	.39	0.99	39.4
November,	3.50	.36	0.79	35.5
*December,	5.90	.74	1.76	42.0
Average,	-	-	-	35.5

Effluent of Septic Tank D-2.

[Parts per 100,000.]

1903.	Free Ammonia.	Albuminoid Nitrogen.	Kjeldahl Nitrogen.	Per Cent. which Nitrogen as Albuminoid Ammonia is of Organic Nitrogen.
April,	3.50	.18	0.61	29.5
May,	3.65	.24	0.62	38.8
June,	4.10	.23	0.62	37.1
July,	4.30	.23	0.71	32.4
August,	4.30	.21	0.49	43.0
October,	5.10	.24	0.62	38.8
November,	4.70	.34	0.66	51.5
December,	5.33	.38	0.82	46.5
Average,	-	-	-	40.4

Effluent of Septic Tank D-5.

April,	3.60	.12	0.57	21.0
May,	3.60	.18	0.52	34.6
June,	4.40	.16	0.44	36.4
July,	4.00	.18	0.52	34.6
August,	4.25	.17	0.43	39.6
October,	4.50	.21	0.55	38.1
November,	4.90	.31	0.48	64.5
December,	5.20	.33	0.71	46.5
Average,	-	-	-	39.6

Sewage for Filter No. 196.

April,	3.50	.36	0.86	41.9
May,	2.55	.26	0.61	42.6
June,	3.60	.39	0.99	39.4
July,	4.16	.36	0.87	41.4
August,	3.65	.50	1.23	40.6
September,	4.83	.42	0.88	47.7
Average,	-	-	-	42.2

Effluent of Filter No. 196.

[Parts per 100,000.]

1903.	Free Ammonia.	Albuminoid Nitrogen.	Kjeldahl Nitrogen.	Per Cent. which Nitrogen as Albuminoid Ammonia is of Organic Nitrogen.
April,	2.30	.16	0.55	29.8
May,	1.69	.23	0.70	32.5
June,	2.81	.25	0.70	35.5
July,	2.61	.23	0.62	36.2
August,	3.88	.21	0.63	33.1
September,	2.78	.23	0.57	40.8
Average,	-	-	-	35.2

Total Organic Nitrogen in Samples of Sewages from Filtration Areas.

Besides the work at the station, over one hundred Kjeldahl determinations have been made in the State House laboratory. This work has been upon the samples of sewage received from different disposal areas in the State, and a table following presents the results of these analyses. A column is given in this table showing the age of the sewage at the time the analysis was made; that is, the period elapsing between collection and examination of each sample.

Samples of Sewages from Filtration Areas.

[Parts per 100,000.]

From	Free Ammonia.	Albuminoid Nitrogen.	Kjeldahl Nitrogen.	Per Cent. which Nitrogen as Albuminoid Ammonia is of Organic Nitrogen.	Age of Sewage in Hours.
Andover,	6.32	0.60	1.33	45.0	7
Andover,	2.92	0.25	0.69	36.8	8
Andover,	0.22	0.07	0.19	34.5	7
Andover,	0.19	0.07	0.20	32.8	8
Andover,	0.18	0.08	0.25	32.8	7
Billerica,	3.12	0.26	0.77	34.1	28
Billerica,	10.00	1.38	4.00	34.4	23
Billerica,	7.60	1.05	2.21	47.4	29
Billerica,	5.20	0.89	2.26	39.2	29
Brockton, sludge,	7.20	2.72	20.96	12.9	26
Brockton, sludge,	8.16	4.79	14.74	32.5	23
Brockton, sludge,	5.60	2.87	12.05	23.8	24

Samples of Sewages from Filtration Areas — Continued.

From	Free Ammonia.	Albuminoid Nitrogen.	Kjeldahl Nitrogen.	Per Cent. which Nitrogen as Albuminoid Ammonia is of Organic Nitrogen.	Age of Sewage in Hours.
Brockton, sludge, ...	4.80	12.71	30.67	41.4	25
Brockton, sludge, ...	4.32	2.56	6.92	37.0	24
Brockton, sludge, ...	5.20	10.00	23.53	42.5	23
Brockton, sewage, ...	5.12	0.67	1.87	35.9	25
Brockton, sewage, ...	2.92	0.89	1.96	45.2	26
Brockton, sewage, ...	4.40	0.85	2.32	36.8	24
Brockton, sewage, ...	3.36	0.72	1.87	38.6	24
Clinton, ...	4.88	1.03	2.18	47.4	24
Clinton, ...	3.52	0.92	2.40	38.3	23
Clinton, ...	4.16	0.47	1.77	26.4	20
Clinton, ...	2.72	0.62	1.80	34.6	22
Clinton, ...	1.72	0.43	1.16	37.5	22
Clinton, ...	3.04	0.46	1.48	31.0	18
Concord, ...	0.90	0.14	0.40	34.8	17
Concord, ...	0.64	0.16	0.65	25.2	20
Concord, ...	1.28	0.36	0.76	47.5	5
Concord, ...	0.76	0.28	0.75	37.2	23
Concord, ...	0.36	0.08	0.47	17.4	6
Concord, ...	0.69	0.13	0.38	34.5	24
Danvers, ...	1.60	0.80	2.53	31.8	24
Danvers, ...	2.24	1.97	3.62	54.4	25
Danvers, ...	1.52	0.92	2.26	40.6	24
Foxborough, ...	1.76	0.47	1.01	46.3	28
Foxborough, ...	1.92	0.62	1.28	48.7	28
Framingham, ...	4.80	0.80	1.80	44.2	24
Framingham, ...	2.84	0.37	0.90	41.0	20
Framingham, ...	1.60	0.35	0.79	44.6	25
Framingham, ...	2.68	2.20	5.19	42.3	9
Framingham, ...	1.80	0.60	1.60	37.4	8
Gardner, old system, ...	2.84	0.67	1.87	36.0	23
Gardner, old system, ...	1.68	0.44	1.49	29.7	23
Gardner, old system, ...	1.36	0.49	1.76	27.9	22
Gardner, old system, ...	1.04	0.50	1.16	43.1	25
Gardner, old system, ...	1.08	0.24	0.68	35.0	23
Gardner, new system, ...	3.96	0.80	2.33	34.1	23
Gardner, new system, ...	4.80	0.73	2.85	25.6	24

Samples of Sewages from Filtration Areas — Continued.

From	Free Ammonia.	Albuminoid Nitrogen.	Kjeldahl Nitrogen.	Per Cent. which Nitrogen as Albuminoid Ammonia is of Organic Nitrogen.	Age of Sewage in Hours.
Gardner, new system,	4.32	0.71	1.86	37.9	23
Gardner, new system,	6.40	0.92	2.50	36.7	25
Hopedale, tank inlet,	3.28	0.57	1.40	40.4	25
Hopedale, tank inlet,	2.68	0.49	2.28	21.6	42
Hopedale, tank inlet,	2.48	0.39	0.76	50.7	47
Hopedale, tank inlet,	1.36	0.44	1.75	25.3	27
Hopedale, tank inlet,	0.88	0.62	1.37	44.9	48
Hopedale, tank outlet,	1.44	0.20	0.60	32.8	25
Hopedale, tank outlet,	1.60	0.25	0.59	43.1	43
Hopedale, tank outlet,	2.52	0.32	0.65	49.2	47
Hopedale, tank outlet,	0.88	0.20	0.74	26.6	26
Hopedale, tank outlet,	1.00	0.18	0.41	44.0	48
Leicester, tank inlet,	2.80	0.31	0.83	37.5	23
Leicester, tank inlet,	6.64	0.84	1.67	50.1	47
Leicester, tank inlet,	1.44	0.25	0.45	54.7	24
Leicester, tank outlet,	4.00	0.47	1.07	43.7	23
Leicester, tank outlet,	1.40	0.21	0.61	33.6	23
Leicester, tank outlet,	3.04	0.39	0.72	53.5	48
Leicester, tank outlet,	2.04	0.24	0.48	49.5	24
Marlborough,	5.20	0.61	1.39	43.7	40
Marlborough,	0.27	0.04	0.18	22.8	25
Marlborough,	0.50	0.07	0.22	29.8	49
Marlborough,	0.08	0.02	0.13	18.9	34
Medfield,	0.96	0.68	1.62	42.0	24
Medfield,	2.24	0.66	1.30	51.1	46
Medfield,	0.92	0.52	1.67	31.4	18
Natick,	1.68	0.24	0.80	29.7	20
Natick,	0.56	0.14	0.48	29.0	22
Natick,	0.35	0.13	0.53	24.8	21
Natick,	0.60	0.31	0.60	51.9	21
Pittsfield,	1.40	0.63	1.52	41.5	144
Pittsfield,	1.92	0.55	1.24	44.3	96
Pittsfield,	1.76	0.46	1.33	34.5	96
Southbridge,	2.20	0.27	0.58	46.7	55
Southbridge,	4.16	0.52	1.20	43.7	51
Southbridge,	0.88	0.18	0.49	36.8	41

Samples of Sewages from Filtration Areas — Concluded.

From	Free Ammonia.	Albuminoid Nitrogen.	Kjeldahl Nitrogen.	Per Cent. which Nitrogen as Albuminoid Ammonia is of Organic Nitrogen.	Age of Sewage in Hours.
Southbridge,	1.68	0.16	0.48	34.2	49
Spencer,	0.68	0.56	1.33	41.9	21
Spencer,	3.60	0.89	1.89	46.9	43
Spencer,	3.92	0.97	2.29	42.3	25
Spencer,	2.08	0.56	1.52	36.7	71
Spencer,	1.88	0.43	0.92	46.3	23
Stockbridge,	1.50	0.20	0.57	34.5	25
Stockbridge,	1.08	0.25	0.69	36.8	24
Stockbridge,	0.52	0.17	0.31	55.5	25
Stockbridge,	1.20	0.20	0.33	59.6	144
Stockbridge,	1.48	0.19	0.52	36.3	72
Wellesley, coke beds, inlet,	6.60	1.31	2.87	45.7	32
Wellesley, coke beds, inlet,	7.36	1.41	3.67	38.4	25
Wellesley, coke beds, inlet,	7.04	1.64	3.25	50.5	25
Wellesley, coke beds, inlet,	4.00	1.13	4.87	23.2	7
Wellesley, coke beds, outlet,	5.40	1.25	2.60	47.9	32
Wellesley, coke beds, outlet,	7.60	1.49	4.17	35.8	25
Wellesley, coke beds, outlet,	6.56	1.25	2.69	46.3	25
Wellesley, coke beds, outlet,	4.00	0.92	3.68	25.3	7
Westborough,	3.12	0.48	1.08	44.8	23
Westborough,	2.12	0.52	1.53	34.3	23
Westborough,	4.88	1.16	2.60	44.8	22
Westborough,	1.84	0.34	0.75	45.9	16
Westborough,	1.48	0.25	0.59	41.7	23
Westborough,	0.68	0.16	0.36	43.3	22

Fatty Matters in Sewage.

During 1903 the fatty matters in the station sewage have been determined regularly, with the results following: —

[Parts per 100,000.]

January,	3.80	August,	4.13
February,	4.49	September,	3.91
March,	5.84	October,	7.20
April,	7.07	November,	7.95
May,	8.93	December,	8.38
June,	5.44		
July,	5.77	Average,	6.08

INTERMITTENT SAND FILTERS NOS. 1 TO 10, INCLUSIVE.

Intermittent sand Filters Nos. 1, 2, 4 and 6 were put into operation during the last part of 1887 and January of 1888. Filter No. 5 B was put into operation March 5, 1898, and Filter No. 9 A in the summer of 1890. Nitrification became established in Filters Nos. 1, 2, 4 and 6 during the spring and summer of 1888, and during a few of the following winters some, or all, of them were generally protected from the weather by a canvas covering, or the trenches of Nos. 2 and 4 covered with boards, as explained in previous reports.

Notwithstanding this cover, nitrification was often very low in these filters during the winter months, and during the winter of 1890–91, when Filter No. 1 was first exposed to winter weather, nitrification practically ceased within the filter. (See Report of 1891, page 443.) With the comparatively weak sewage applied to the filters during these first years, and with the well-known absorption of free ammonia by fresh or unused sand, even low nitrification produced good effluents, although much of the free and albuminoid ammonia of the applied sewage did not appear as nitrates in the effluents.

The surface sand of these filters gradually became so clogged with organic matter, however, and nitrification became so feeble that it was deemed necessary to remove, during 1892 and 1893, from Filters Nos. 1 and 6, 9 and 4 inches in depth of sand, respectively. During the same years 4½ inches in depth of sand were removed from the trenches in Filter No. 2, and 3½ inches from the surface sand of the trenches in Filter No. 4. From Filter No. 9 A, up to 1894, 11 inches in depth of sand were removed. All the filters received clean sand to fill up to grade in place of the removed sand. That is, after Filters Nos. 1, 2, 4 and 6 had been in operation four or five years they had accumulated so much organic matter that, in order to cause good nitrification, it was considered necessary to remove this large amount of sand. Various experiments to remove organic matter had been made previously, especially with Filter No. 1, by so arranging the surface that only a portion of the filter would be flooded while other portions of the surface sand were allowed to rest; but these attempts to remove the organic matter by this method of encouraging bacterial action did not seem to be successful. Since 1893 (a period of eleven years) no sand has been removed from any of the filters, and their successful operation has been aided by the custom followed of spading over the surface of each 6 to 8 inches deep at least twice a year and raking the surface once each week, corresponding to what can be done on a large scale by ploughing and harrowing. With Filters Nos. 2 and 4, for a number of years following 1893, the coarse sand in the trenches, to which the sewage is applied, was removed occasionally, the bottom of these trenches spaded over several inches deep, the sides scraped and the coarse sand replaced. This treat-

ment of the sand in the trenches, however, was not followed from 1896 until the fall of 1903, a period of six years.

Gradually the difficulty of obtaining good winter results from these filters has increased, and poor nitrification in winter has occurred, beginning with the winter of 1900–01 ; but this condition did not prevail during the winter of 1903–04, as will be explained later in the report. It would obviously have been easy by again removing 6 or 10 inches of the surface sand to obtain as good results as followed this removal in 1892 and 1893. This method of treatment, however, has not been followed, as, beginning in 1893, the theory of operation has been to so care for the upper portion of each filter that serious clogging would not occur and sand removal thus be perhaps made unnecessary. The organic matter stored in these filters has increased very slowly during the past ten years, and the sewage applied to them has generally passed below the surface of the sand as rapidly as during the years following sand removal. There is, nevertheless, an upper layer of sand 6 or 8 inches in depth on Filters Nos. 1, 6 and 9 A that contains a large amount of organic matter, and the trenches in Filters Nos. 2 and 4 contain very dirty sand.

It is evident that the decrease in satisfactory purification of sewage has been almost entirely due to poorer winter nitrification of late years than formerly, and this has occurred notwithstanding the fact that, as far as disposing of the sewage applied is concerned, the filters have been working as well as during the winters of best nitrification ; that is, the sewage has passed below the surface of the filters as readily. When it was deemed necessary to remove clogged sand from these filters, in 1892 and 1893, the summer purification even was poor. (See Filter No. 1, page 426, and Filter No. 4, page 429, Report of 1892.) This has not been the case of late years, however.

In the fall of 1903 special efforts were made to keep the filters in such a condition that nitrification would continue throughout the ensuing winter, and also to study the causes that had combined to prevent nitrification in these filters. In the first place, although the sewage applied to all of the filters had disappeared from the surface of each in a very few minutes during the summer months, and as rapidly as usual during the winter months, Filters Nos. 1, 6, 9 A and 10 were spaded over 2 or 3 inches deeper than usual, and the trenches of coarse sand in Filters Nos. 2 and 4 were removed, the bottoms of the trenches dug over and the sides scraped, as in earlier years, and then the coarse sand replaced. The rates of operation, moreover, of Filters Nos. 1, 6 and 9 A were reduced to 60,000 gallons per acre daily, the usual rate of operation of these filters, although during the early part of 1903 the rates had been somewhat higher than this. Besides this, beginning November 10 all sewage pumped to the station was passed through an aerator before flowing to the filters in order to remove from it as large a per cent. as possible of the gaseous products of putrefaction formed in the sewer pipe; this being done as it had been shown that septic sewage was more easily purified after aeration than when applied

directly to the filters from the septic tanks, and the station sewage is much more stale when applied to the filters than was formerly the case. That this is so is shown by the great increase of the free compared with the albuminoid ammonia of the sewage of late years. During the first few years of operation of the station the free ammonia was from two to three times as great as the albuminoid ammonia, but of late years it has been often six and seven times as great. A table showing the change in this ratio as sewage ages is given in the report of the Board of 1894, page 461, and attention has been frequently called to it in various subsequent reports.

Notwithstanding the deep disturbance of the filters and the aeration of the sewage, the nitrates in the effluents of Filters Nos. 1, 6 and 9 A began to diminish rapidly during the latter part of October and the first few days of November, 1903, although the sewage applied each day during these weeks disappeared from the surface in the following times: from Filter No. 1, generally in less than ten minutes; from the surface of Filter No. 6, in from ten to fifty minutes; and from the surface of Filter No. 9 A, from ten minutes to one hour. Hence, to make further effort to encourage the continuance of nitrification, the surface of each of these filters was arranged during the second week of December as follows: on about two-thirds of the surface of Filters Nos. 1, 6 and 9 A, 3 inches in depth of sand were removed, this sand being piled up on the remaining portion of the filter and the sewage applied to the portion thus made lower than the surrounding surface.

This arrangement accomplished four results. First, the sewage applied to a smaller area did not have so large a surface exposed to the air, hence it had a tendency to keep warmer and enter the filter more rapidly than when applied to the entire surface; second, the sewage had a smaller distance of clogged or dirty sand to pass through than before the arrangement was made; third, the entire surface of the filter could never become covered with either sewage or ice, as sometimes occurred during cold winter weather when the entire surface had been flooded; and fourth, the resting of a considerable portion of the upper layers of the sand. At filtration areas of the State, furrowing the area gives the same results; that is, the application of sewage to a small portion of the area. Methods of surface arrangement similar to this had been tried during previous years but without marked increase in nitrification; in fact, this manner of arrangement and flooding had tended to cause poor results, owing to the too rapid passage of sewage through the filter. That it was successful at this time was undoubtedly due to the greater age of the filters and the accumulation of organic matter within them.

Following this arrangement of the filters, nitrification was maintained in them through the winter of 1903–04. It must be noted, however, that as the rate of operation of these filters was about 60,000 gallons per acre daily for the entire surface, the rate of operation was about 90,000 gallons per acre daily for the area flooded, but this was no greater than for the entire

filter during some of the previous winters, when nitrification ceased within them. Nitrification was also active during the winter of 1903–04 in Filters Nos. 2, 4, 5 B and 10. Filters Nos. 2 and 4 were operated as during previous winters when nitrification had ceased, although the trenches of these two filters received more thorough treatment during the autumn of 1903 than they had for several years, as already stated. Filter No. 5 B was operated at a lower rate than during the preceding winter. Filter No. 10, however, was operated at the same rate. While nitrification had been fairly active in Filters Nos. 5 B and 10 during the previous winters, when it had practically ceased in Filters Nos. 1, 2, 4, 6 and 9 A, still during the winter of 1903–04 nitrification was stronger in these two filters than during previous winters. The time taken for the sewage to disappear from the surface of the filters has apparently been a little less than during the three previous winters, although this winter of 1903–04 was the coldest in the history of the station.

A possible reason for poor nitrification during previous winters, the high free ammonia in the effluents of these filters during these winters, and, indeed, at times during the winter of 1903–04, is as follows.

It seems probable that in the winter there has been of late years — perhaps owing to the accumulation of organic matter in the upper sand of these filters and perhaps owing to more complete destruction than formerly of the oxidizing bacteria of the sewage before this sewage reaches the station — a rapid increase of anaerobic bacteria in the filters, or at least bacteria that will aid in the formation of ammonia but not of nitrates. In order to study different suppositions as to the cause of the winter non-nitrification problem a number of experiments have been made.

In the first, a series of tube filters was started as follows, these filters being Nos. 226, 227, 228, 229, 230 and 231. Filters Nos. 226, 227 and 228 were filled with 4½ feet in depth of fresh, clean sand. The sand of Filter No. 226 was first sterilized by heat and to this filter station sewage was applied. The sand in Filter No. 227 was not sterilized but the sewage applied each day was. Filter No. 228 was constructed of unsterilized sand, and unsterilized station sewage was applied daily. Filter No. 229 was filled with 4½ feet in depth of dirty sand from the surface of Filter No. 1, and Filter No. 230 with like sand mixed with a small percentage of marble dust. Filter No. 231 was filled with clean sand and received regular station sewage, to which enough sodium carbonate was added daily to unite with the nitric acid formed by the oxidation of the nitrogen of the ammonia in the sewage. All of these filters were kept at temperatures of about 65 degrees F.

Filters Nos. 226, 227 and 228 were kept in operation about seven weeks. Nitrification did not begin in the filter in which the sand was sterilized until three weeks from the beginning of operation; the filter receiving sterilized sewage, No. 227, gave quicker and better nitrification than the similar filter receiving unsterilized sewage, No. 228, but in about three weeks approximately the same results were being obtained from each of

these filters; that is, the results from these three filters seemed to show (1) that a quick beginning of nitrification was due to bacteria in the sand rather than in the sewage, and that if the sand was sterilized nitrification was delayed; (2) that other things being the same, a filter receiving sterilized station sewage gave quicker and better nitrification than a filter receiving unsterilized sewage, this seeming to indicate bodies or bacteria normally present in the sewage that are more or less inimical to nitrification.

Filter No. 229 was, as stated, constructed of sand taken from the surface of Filter No. 1 during a period of comparatively low nitrification in this filter, and this sand had been frozen just previous to being taken from Filter No. 1. This sand contained 0.50 parts of free ammonia. In this filter nitrification did not begin until a period of three weeks had elapsed, and then only feebly. From the beginning of operation, however, of this small filter, the free ammonia in its effluent was much greater than in the sewage applied to it, showing some oxidation occurring but not the complete change to nitrates. In Filter No. 230, however, filled with similar sand from Filter No. 1, but containing a small amount of marble chips, nitrification became immediately active, and the nitrates were as high as 10 and 12 parts, together with an amount of free ammonia that was for several weeks double the amount in the applied sewage; the operation of these two filters seeming to indicate that the lack of sufficient lime or a similar base in Filters Nos. 1, 6, 9 A, etc., was one of the reasons for high free ammonia and low nitrates in these filters during recent winters.

Beginning Feb. 1, 1904, a second series of similar experiments, with one or two additions, was again started, and during this series the filters were maintained at a lower temperature than during the first series. Other experiments on this subject are under way.

Filter No. 226.

Four and one-half feet of sand, effective size 0.27. Sterile sand and sterile tube. Filter received regular sewage at a rate of 50,000 gallons per acre daily. Started Dec. 4, 1903.

Effluent of Filter No. 226.

[Parts per 100,000.]

Days from Start.	Temperature.	Turbidity.	Sediment.	Color.	Free Ammonia.	Total Albuminoid Ammonia.	Nitrates.	Nitrites.	Oxygen Consumed	Bacteria per Cubic Centimeter.
5,	67	V. slight.	Slight.	Slight.	.2100	.1440	0.04	.0180	.80	250,000
12,	65	0	V. slight	.41	.1720	.0460	0.02	.0028	12	400,000
19,	65	0	0	.32	.2000	.0360	0.02	.0950	0.61	200,000
26,	61	0	0	.36	.2800	.0280	1.52	.3300	0.44	105,000
33,	65	0	0	.25	.5000	.2000	5.03	.0080	0.53	42,000
40,	62	0	0	.16	.6250	.0280	3.69	.0600	0.31	20,000
47,	63	0	0	.14	.3900	.0200	2.72	.1400	0.34	25,000
54,	65	0	0	.16	1600	.0220	4.12	.0800	0.32	5,000

Filter No. 227.

Four and one-half feet of sand of an effective size of 0.27. Unsterilized sand and tube. Sewage sterilized by heat daily. Rate, 50,000 gallons per acre daily. Started Dec. 4, 1903.

Effluent of Filter No. 227.

[Parts per 100,000.]

Days from Start.	Temperature.	Turbidity.	Sediment.	Color.	Free Ammonia.	Total Albuminoid Ammonia.	Nitrates.	Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
5,	67	0	0	V. slight.	.6200	.0460	1.61	.0760	1.13	24,000
12,	65	0	0	.30	.4080	.0280	1.97	.2200	0.59	13,400
19,	65	0	0	.30	.1350	.0240	2.85	.0900	0.44	5,600
26,	61	0	0	.25	.0280	.0200	3.46	.0028	0.38	3,100
33,	65	0	0	.23	.0080	.0160	3.47	.0008	0.38	4,800
40,	62	0	0	.18	.0100	.0220	3.48	.0006	0.30	10,000
47,	63	0	0	.22	.0060	.0160	3.58	.0004	0.36	2,000
54,	65	0	0	.20	.0060	.0180	4.28	.0002	0.34	1,100

Filter No. 228.

Five feet of sand of an effective size of 0.27. Unsterilized sand and tube. Rate, 50,000 gallons of regular sewage per acre daily. Started Dec. 4, 1903.

Effluent of Filter No. 228.

[Parts per 100,000.]

Days from Start.	Temperature.	Turbidity.	Sediment.	Color.	Free Ammonia.	Total Albuminoid Ammonia.	Nitrates.	Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
5,	67	0	0	V. slight.	.3500	.0340	1.25	.0240	.95	49,000
12,	65	0	0	.22	.0400	.0200	1.15	.0300	.43	9,000
19,	65	0	0	.20	.0100	.0220	2.60	.0004	.34	3,800
26,	61	0	0	.15	.0060	.0180	5.05	.0012	.24	5,000
33,	65	0	0	.15	.0040	.0100	4.02	.0008	.28	1,700
40,	62	0	0	.08	.0040	.0140	3.75	.0000	.36	500
47,	63	0	0	.11	.0060	.0100	3.93	.0002	.22	600
54,	65	0	0	.10	.0020	.0220	4.28	.0000	.22	600

Filter No. 229.

Four feet of sand. Sand taken from surface of Filter No. 1. Rate, 50,000 gallons of regular sewage per acre daily. Started Dec. 4, 1903.

Effluent of Filter No. 229.

[Parts per 100,000.]

Days from Start.	Temperature.	Turbidity.	Sediment.	Color.	Free Ammonia.	Total Albuminoid Ammonia.	Nitrates.	Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
5, ...	67	Slight.	V. slight.	Yellow.	11.6000	-	.07	.0015	10.00	5,090,500
12, ...	65	Slight.	V. slight.	Yellow.	9.7500	.9500	.05	.0000	6.80	1,150,000
19, ...	65	Great.	V. slight.	Yellow.	9.7500	.7000	.04	.0200	4.78	10,000
26, ...	61	Great.	V. slight.	Yellow.	11.0000	.4800	.54	.0950	4.49	210,000
33, ...	65	Decided.	Slight.	Yellow.	7.4000	.3200	.28	.0600	3.13	110,500
40, ...	62	Decided.	V. slight.	Yellow.	7.4000	.4600	.23	.0600	2.83	280,000
47, ...	63	Slight.	V. slight.	Yellow.	6.8750	.4400	.03	.0100	2.99	1,134,000
54, ...	65	Slight.	V. slight.	Yellow.	5.1250	-	.18	.0020	2.20	619,000

Filter No. 230.

Four feet of sand. Sand taken from surface of Filter No. 1 and mixed with $\frac{1}{20}$ its volume of fine marble chips. Rate, 50,000 gallons of regular sewage per acre daily. Started Dec. 4, 1903.

Effluent of Filter No. 230.

[Parts per 100,000.]

Days from Start.	Temperature.	Turbidity.	Sediment.	Color.	Free Ammonia.	Total Albuminoid Ammonia.	In Solution.	Nitrates.	Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
5, . . .	67	Decided.	V. slight.	Yellow.	10.4000	4.0000	-	0.15	0.0000	14.80	25,452,000
12, . . .	65	Slight.	V. slight.	Yellow.	5.7500	1.7000	1.7000	0.07	0.0000	8.40	7,250,000
19, . . .	65	V. slight.	V. slight.	Yellow.	7.2500	1.0500	0.9500	0.26	0.2400	3.33	240,000
26, . . .	61	V. slight.	V. slight.	Yellow.	8.6000	0.7000	0.5200	4.18	1.2000	3.23	3,692,000
33, . . .	65	Slight.	V. slight.	Yellow.	8.0000	0.3900	0.2900	10.03	0.5500	1.77	90,000
40, . . .	62	V. slight.	V. slight.	Yellow.	5.0000	0.2200	0.1900	12.30	0.1400	1.44	45,000
47, . . .	63	V. slight.	V. slight.	Yellow.	2.9000	0.1300	-	9.17	0.0760	1.11	29,000
54, . . .	65	Slight.	Slight.	Yellow.	2.0000	0.1100	-	7.30	0.0500	1.64	8,500

Filter No. 231.

Three and one-half feet of sand of an effective size of 0.27. Sterile sand and sterile tube. Rate, 50,000 gallons per acre daily. Sodium carbonate. Started Dec. 4, 1903.

Effluent of Filter No. 231.

[Parts per 100,000.]

Days from Start.	Temperature.	Turbidity.	Sediment.	Color.	Free Ammonia.	Total Albuminoid Ammonia.	Nitrates.	Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
5,	67	0	V. slight	V. slight.	.5000	.1180	0.09	.0080	-	250,000
12,	65	V. slight.	0	.78	.3200	.1000	0.02	.0280	1.25	440,000
19,	65	V. slight.	0	V. slight.	.4400	.0780	0.30	.4400	0.94	200,000
26,	61	0	0	V. slight	.7000	.0560	6.32	.5600	0.74	115,000
33,	65	V. slight.	0	V. slight.	.6600	.0440	4.69	.0090	0.75	95,000
40,	62	V. slight.	V. slight.	.42	.5000	.0500	4.16	.0360	0.72	97,000
47,	63	0	0	V. slight.	.1700	.0500	4.13	.0300	0.71	35,500
54,	65	V. slight.	0	V. slight.	.0520	.0560	2.51	.0120	0.71	79,500

Filter No. 1.

Filter No. 1 is constructed of 60 inches in depth of coarse sand of an effective size of 0.48 millimeter, and is $\frac{1}{200}$ of an acre in area. The surface of this filter has been raked 1 inch deep each week and spaded over to a depth of 10 inches July 12 and September 19, and to a depth of 6 inches November 10. During January, $2\frac{1}{2}$ inches of snow and $3\frac{3}{8}$ inches of ice were removed from the surface; during February, $14\frac{1}{2}$ inches of snow and $2\frac{1}{2}$ inches of ice; and during December, 6 inches of snow and $5\frac{7}{8}$ inches of ice. The filter was allowed to rest April 6 to 12, inclusive, and September 23 to 27, inclusive. Upon December 10 the surface of the filter was so arranged that the sewage during the winter of 1903–04 should be applied to about two-thirds of this surface; that is, from a circular section, 13 feet in diameter, 3 inches in depth of sand were removed and piled around the edge of the filter, the sewage being applied to this low area.

Filter No. 2.

This filter is $\frac{1}{200}$ of an acre in area and is constructed of 60 inches in depth of fine sand of an effective size of 0.08 millimeter, with circular trenches 1 foot wide and 2 feet deep of medium sand of an effective size of 0.19 millimeter, the surface of these trenches being below the surface of the remainder of the filter, and the sewage is applied to them. The surface of these trenches has been raked 1 inch deep each week during the year. Upon April 9 the trenches were spaded over to a depth of 6 inches; upon July 12 to a depth of 12 inches, and upon August 16 all of the sand in both trenches was removed, the fine sand at the bottom of the trenches dug over 4 inches deep, the sides of the trenches raked and then the sand replaced.

The ridges were also dug over upon this date to a depth of 6 inches. During January, $3\frac{1}{2}$ inches of snow and $4\frac{3}{8}$ inches of ice were removed from the trenches; during February, 9 inches of snow and $2\frac{3}{4}$ inches of ice were removed; and during December, 6 inches of snow were removed from the trenches. The filter was allowed to rest April 6 to 12, inclusive, and July 11 to 19, inclusive.

Filter No. 4.

Filter No. 4 is $\frac{1}{200}$ of an acre in area and is constructed of 60 inches in depth of fine river silt of an effective size of 0.04 millimeter, with two circular trenches about 14 inches wide and 12 inches deep, of coarse sand of an effective size of 0.48 millimeter. The surface of these trenches is below the remainder of the filter and to them the sewage is applied. They have been raked 1 inch deep each week and spaded to a depth of 6 inches on April 9 and 10 inches on July 12. Upon August 18 the sand in both trenches, was removed, the bottoms of these trenches dug over 4 inches deep, the sides raked and the sand replaced. The ridges between the trenches were also dug over at this time to a depth of 6 inches. During January, 2 inches of snow and $6\frac{7}{8}$ inches of ice were removed from the filter; during February, 13 inches of snow and $2\frac{3}{4}$ inches of ice; and during December, 6 inches of snow. The filter was allowed to rest April 6 to 12, inclusive, and July 11 to 19, inclusive.

Filter No. 5 B.

This filter is $\frac{1}{200}$ of an acre in area and is constructed of 60 inches in depth of a mixture of cinders and ashes from the combustion of soft coal. It was first put into operation March 5, 1898. The surface of the filter has been raked 1 inch deep each week and the filter allowed to rest April 6 to 12, inclusive, and July 12 to 19, inclusive. During January, 3 inches of snow and $6\frac{5}{8}$ inches of ice were removed from the filter; during February, $15\frac{1}{2}$ inches of snow and $2\frac{1}{4}$ inches of ice were removed; during December, 5 inches of snow and $9\frac{3}{4}$ inches of ice.

Filter No. 6.

This filter is $\frac{1}{200}$ of an acre in area and is 44 inches in depth of mixed coarse and fine sand of an effective size of 0.35 millimeter. The surface of the filter has been raked to a depth of 1 inch each week and spaded to a depth of 6 inches April 9 and 10 inches July 12 and September 23. During January, $4\frac{1}{2}$ inches of snow and $3\frac{7}{8}$ inches of ice were removed from the filter; during February, 14 inches of snow and $\frac{5}{8}$ of an inch of ice; and during December, 6 inches in depth of snow were removed. On December 10 the surface of this filter was so arranged that the sewage was applied during the winter of 1903–04 to about two-thirds of the surface; that is, a circular area, 13 feet in diameter, was dug out to a depth of 3 inches, this sand piled around the edges of the filter and the sewage applied to this low area.

Filter No. 9 A.

This filter is $\frac{1}{200}$ of an acre in area and is constructed of 5 feet in depth of sand of an effective size of 0.17 millimeter. The surface was raked 1 inch deep each week and spaded over to a depth of 6 inches January 23, 6 inches April 9, 10 inches July 12 and September 21, and 6 inches November 10. On December 10 the surface was so arranged that sewage was applied to about two-thirds of the surface during the winter of 1903–04; that is, upon a circular area of 13 feet in diameter, 3 inches in depth of sand were removed, piled around the edges of the filter and the sewage applied to this low area. During January, 2½ inches in depth of snow and 2⅜ inches of ice were removed; during February, 15½ inches of snow and ⅜ of an inch of ice, and during December, 4½ inches of snow were removed.

Filter No. 10.

This filter is $\frac{1}{200}$ of an acre in area and is constructed of 5 feet in depth of mixed fine and coarse sand of an effective size of 0.35 millimeter. No underdrains are beneath the sand except directly above and around the outlet pipe. A partition extending 3 feet below the surface separates the quarter of the surface farthest from the underdrains from the remainder of the surface. To this quarter of the surface the sewage is applied, and over the remainder of the surface is a layer of loam 8 inches in depth. The surface of the filter has been raked 1 inch deep each week and spaded to a depth of 6 inches April 9, 10 inches July 12, August 17 and September 23. The filter was allowed to rest from April 6 to 12, inclusive, and July 11 to 19, inclusive. During January, 4¼ inches of snow and 2 inches of ice were removed from the filter; during February, 17 inches of snow and 2⅞ inches of ice; and during December, 6 inches of snow.

Effluent of Filter No. 1.

[Parts per 100,000.]

1903.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. Sewage.	Temperature. Deg. F. Effluent.	Length of Time Sewage Remained on Surface. Hours and Minutes.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. In Solution.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Jan., .	96,300	50	37	3h. 43m.	Slight.	0.69	3.1680	.1232	.1165	7.43	0.03	.0009	1.07	208,000
Feb., .	90,800	46	37	1h. 16m.	Slight.	0.75	3.3900	.0920	.0860	6.59	0.03	.0001	1.09	56,950
Mar., .	96,100	49	42	1h. 42m.	V. slight.	0.71	4.2567	.0920	-	6.45	0.22	.0007	1.01	55,600
Apr., .	76,900	49	48	46m.	Slight.	0.49	2.9600	.0840	-	8.25	1.73	.0045	0.79	56,200
May, .	88,500	60	55	9m.	Slight.	0.15	1.5000	.0680	-	9.08	7.74	.0018	0.57	411,200
June, .	74,600	62	64	9m.	Slight.	0.38	0.2240	.0850	-	11.01	4.61	.0018	0.63	105,800
July, .	56,300	69	70	2m.	Slight.	0.30	0.3227	.0820	-	18.81	5.35	.0014	0.58	107,800
Aug., .	67,700	67	69	3m.	V. slight.	0.20	0.1435	.0376	-	12.04	4.46	.0004	0.39	26,800
Sept., .	43,800	66	69	2m.	None.	0.14	0.0233	.0232	-	14.61	4.70	.0003	0.25	10,400
Oct., .	60,000	56	60	9m.	V. slight.	0.22	0.4194	.0384	-	12.80	2.92	.0001	0.36	16,700
Nov., .	55,200	51	47	10m.	V. slight.	0.56	1.4625	.0730	-	13.17	1.08	.0001	0.83	19,500
Dec., .	57,800	50	40	-	Slight.	1.16	3.2367	.1697	-	11.70	0.83	.0025	1.49	70,700
Av.,	72,000	56	53	-	-	0.48	1.7580	.0807	.1012*	11.00	2.81	.0012	0.76	95,471

* Average for two months.

Effluent of Filter No. 2.

[Parts per 100,000.]

1903.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. Sewage.	Temperature. Deg. F. Effluent.	Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January, .	34,100	49	37	16h. 38m.	None.	.24	0.7580	.0300	7.20	0.30	.0000	0.44	530
February, .	35,000	46	36	3h. 30m.	V. slight	.67	2.0267	.0767	7.33	0.11	.0001	1.10	1,475
March, . .	32,300	46	38	19m.	None.	.77	3.6250	.0780	7.70	0.09	.0000	1.13	104
April, . .	30,800	51	45	15m.	None.	.61	3.6533	.0667	6.54	1.71	.0003	0.82	72
May, . .	32,900	59	53	8m.	None.	.25	3.6000	.0480	7.91	4.45	.0006	0.46	47
June, . .	32,300	61	61	9m.	None.	.19	1.4550	.0520	9.44	7.81	.0129	0.27	51
July, . .	28,200	69	66	5m.	None.	.17	0.0183	.0211	9.31	3.61	.0004	0.24	33
August, .	35,400	67	67	5m.	None.	.15	0.0024	.0213	13.69	5.24	.0001	0.23	22
September, .	36,900	66	68	4m.	None.	.11	0.0021	.0154	12.59	4.85	.0000	0.19	1,106
October, .	40,000	56	61	9m.	None.	.10	0.0154	.0113	12.60	4.21	.0001	0.18	105
November, .	40,000	51	50	25m.	None.	.13	0.1838	.0258	11.47	7.37	.0100	0.22	20
December, .	38,400	48	42	-	None.	.17	0.7417	.0233	11.59	1.67	.0367	0.42	235
Average,	34,700	56	52	-	-	.30	1.3401	.0391	9.70	3.20	.0051	0.48	317

Effluent of Filter No. 4.

January, .	17,800	48	37	17h. 42m.	None.	.09	0.0478	.0158	7.69	0.99	.0002	0.17	84
February, .	16,700	47	37	6h. 6m.	None.	.13	0.1951	.0193	7.78	0.27	.0000	0.25	42
March, . .	27,700	46	40	54m.	None.	.16	0.3580	.0215	7.74	0.14	.0001	0.33	47
April, . .	15, 0 0	51	45	16m.	None.	.25	0.7383	.0273	6.53	0.95	.0000	0.42	38
May, . .	15,400	59	54	7m.	None.	.13	0.9250	.0240	5.92	3.02	.0000	0.24	15
June, . .	18,500	61	62	7m.	None.	.08	1.0100	.0190	9.59	6.38	.0009	0.18	21
July, . .	11,900	69	69	7m.	None.	.09	0.0465	.0161	8.12	4.25	.0001	0.15	9
August, .	16,900	67	66	7m.	None.	.07	0.0180	.0144	11.26	4.40	.0000	0.17	25
September, .	20,000	66	66	4m.	None.	.07	0.0048	.0134	13.07	4.86	.0000	0.14	259
October, .	20,700	57	60	8m.	None.	.06	0.0019	.0112	13.01	4.86	.0000	0.17	217
November, .	19,200	50	49	8m.	None.	.09	0.0020	.0106	11.28	4.20	.0000	0.13	145
December, .	17,800	48	44	-	None.	.08	0.0077	.0099	10.08	2.90	.0000	0.13	58
Average,	18,200	56	52	-	-	.11	0.2796	.0169	9.34	3.10	.0001	0.21	80

Effluent of Filter No. 5 B.

[Parts per 100,000.]

1903.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. Sewage.	Temperature. Deg. F. Effluent.	Length of Time Sewage Remained on Surface. Hours and Minutes.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. In Solution.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Jan., .	128,600	47	38	6h. 5m.	Decided.	1.04	3.5840	.1440	-	8.84	0.55	.0019	1.19	123,700
Feb., .	113,800	46	36	3h. 5m.	Slight.	0.78	2.9133	.1560	.1293	8.76	1.05	.0018	1.29	209,500
Mar., .	106,900	46	42	50m.	Slight.	0.77	2.9900	.1300	.1260	9.83	0.80	.0008	1.07	422,500
Apr., .	115,400	52	49	51m.	V. slight.	0.35	1.5733	.0507	-	9.54	2.21	.0005	0.55	29,300
May, .	86,300	58	55	9m.	V. slight.	0.27	1.2500	.0320	-	10.21	2.77	.0004	0.50	22,000
June, .	90,000	61	63	14m.	V. slight.	0.24	0.5100	.0480	-	10.50	5.96	.0005	0.42	17,300
July, .	70,400	70	71	6m.	V. slight.	0.26	0.7425	.0710	.0410	13.53	4.62	.0005	0.50	26,800
Aug, .	79,600	67	70	6m.	V. slight.	0.24	0.3830	.0560	-	11.72	4.58	.0013	0.48	18,000
Sept, .	61,900	66	68	4m.	None.	0.13	0.0661	.0253	-	13.52	5.08	.0000	0.28	1,375
Oct., .	70,000	56	60	4m.	V. slight.	0.28	0.6867	.0393	-	12.65	4.01	.0002	0.46	18,500
Nov., .	70,000	51	49	11m.	Slight.	0.51	2.1667	.0807	-	12.03	2.38	.0011	0.91	32,600
Dec, .	87,400	50	39	-	Slight.	0.86	3.7875	.1513	-	10.30	1.42	.0069	1.24	116,700
Av.,	90,000	56	53	-	-	0.48	1.7228	.0820	.0988*	10.96	2.95	.0013	0.74	86,100

* Average for three months.

Effluent of Filter No. 6.

1903.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. Sewage.	Temperature. Deg. F. Effluent.	Length of Time Sewage Remained on Surface. Hours and Minutes.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. In Solution.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Jan., .	96,300	47	36	6h. 28m.	Slight.	0.80	3.5200	.1264	.1190	8.00	0.03	.0000	1.15	48,100
Feb., .	87,500	48	35	5h. 55m.	V. slight.	0.82	3.3200	.1000	.0960	6.93	0.03	.0000	1.03	38,900
Mar., .	69,200	45	42	1h. 23m.	V. slight.	0.71	3.7500	.0860	-	8.21	0.18	.0002	0.97	38,700
Apr., .	80,000	51	48	56m.	V. slight.	0.49	3.0533	.0653	-	8.67	1.37	.0074	0.68	20,200
May, .	84,600	59	55	12m.	V. slight.	0.50	2.1500	.0920	-	10.68	1.34	.0080	0.80	48,000
June, .	73,200	62	64	17m.	V. slight.	0.27	0.2340	.0382	-	10.42	5.67	.0055	0.59	19,900
July, .	56,300	69	72	2m.	None.	0.21	0.0351	.0415	-	12.40	4.98	.0007	0.34	7,070
Aug., .	67,700	67	69	5m.	None.	0.18	0.0065	.0296	-	10.87	4.77	.0000	0.29	4,800
Sept., .	48,500	66	69	3m.	None.	0.16	0.0020	.0230	-	13.94	5.91	.0001	0.23	1,700
Oct., .	60,000	56	57	6m.	None.	0.16	0.2300	.0200	-	12.08	3.74	.0001	0.21	1,633
Nov, .	58,800	51	48	57m.	V. slight.	0.33	1.0500	.0570	-	11.04	1.93	.0007	0.46	10,000
Dec., .	60,000	50	39	-	V. slight.	0.75	1.7600	.1033	-	9.55	0.52	.0010	1.08	6,800
Av.,	70,200	56	53	-	-	0.46	1.5926	.0652	.1075*	10.23	2.54	.0020	0.65	20,500

* Average for two months.

Effluent of Filter No. 9 A.

[Parts per 100,000.]

1903.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. — Sewage.	Temperature. Deg. F. — Effluent.	Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance. — Turbidity.	Appearance. — Color.	Ammonia. — Free.	Ammonia. — Albuminoid. — Total.	Ammonia. — Albuminoid. — In Solution.	Chlorine.	Nitrogen as — Nitrates.	Nitrogen as — Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Jan., .	96,300	52	39	2h. 26m.	V. slight.	0.76	2.9467	.1040	.0864	7.43	0.07	.0003	0.97	109,000
Feb., .	87,500	53	40	2h.	V. slight.	0.62	2.8875	.0910	-	7.50	0.11	.0003	0.90	39,200
Mar., .	65,400	50	44	1h. 21m.	V. slight.	0.62	2.9950	.0640	-	7.61	0.33	.0005	0.78	21,700
Apr., .	80,800	52	49	28m.	V. slight.	0.55	2.3167	.0560	-	7.34	1.85	.0014	0.68	15,700
May, .	80,800	60	56	13m.	V. slight.	0.26	0.8000	.0420	-	9.99	4.45	.0028	0.45	16,000
June, .	71,600	62	63	25m.	None.	0.20	0.0206	.0255	-	10.60	3.83	.0000	0.32	4,100
July, .	59,300	68	70	2m.	V. slight.	0.21	0.0151	.0385	-	13.20	5.70	.0003	0.33	9,600
Aug., .	67,700	67	69	5m.	None.	0.16	0.0034	.0232	-	14.43	3.49	.0000	0.24	900
Sept., .	46,200	66	69	6m.	None.	0.14	0.0083	.0186	-	14.18	4.94	.0001	0.21	92
Oct., .	60,000	56	60	14m.	None.	0.16	0.3212	.0242	-	12.95	3.08	.0000	0.26	433
Nov., .	55,200	52	50	1h. 12m.	None.	0.45	1.2125	.0510	-	12.80	2.64	.0001	0.66	1,700
Dec., .	60,000	58	41	-	Slight.	1.18	2.7000	.1457	-	9.63	0.95	.0014	1.49	100,000
Av.,	69,200	58	54	-	-	0.44	1.3523	.0570	-	10.64	2.62	.0006	0.61	26,500

Effluent of Filter No. 10.

[Parts per 100,000.]

1903.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. — Sewage.	Temperature. Deg. F. — Effluent.	Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance. — Turbidity.	Appearance. — Color.	Ammonia. — Free.	Ammonia. — Albuminoid.	Chlorine.	Nitrogen as — Nitrates.	Nitrogen as — Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January, .	27,800	47	42	5h. 17m.	V. slight.	.33	1.1110	.0560	6.49	0.59	.0000	.51	1,100
February, .	26,300	46	39	1h. 13m.	V. slight.	.53	2.1000	.0693	.38	0.50	.0000	.78	1,600
March, .	16,200	47	42	10m.	V. slight.	.44	1.7600	.0550	.53	1.47	.0000	.68	3,850
April, .	23,100	52	47	17m.	V. slight.	.31	1.5833	.0413	.46	2.41	.0003	.43	2,067
May, .	23,100	60	52	3m.	None.	.14	0.7000	.0280	9.72	3.78	.0000	.36	1,000
June, .	23,100	61	62	4m.	None.	.23	0.0991	.0274	10.15	4.67	.0037	.30	2,800
July, .	21,100	68	67	2m.	None.	.17	0.0183	.0301	10.99	3.36	.0003	.29	800
August, .	24,200	67	67	2m.	None.	.18	0.0706	.0242	.58	3.82	.0005	.28	475
September, .	15,400	66	67	2m.	None.	.18	0.0385	.0238	.18	4.28	.0007	.26	3,600
October, .	20,000	56	61	7m.	V. slight.	.19	0.1137	.0234	13.65	3.98	.0003	.28	650
November, .	20,000	51	52	31m.	V. slight.	.17	0.3050	.0200	17.74	2.44	.0000	.27	1,000
December, .	20,000	48	46	-	V. slight.	.19	0.7867	.0307	10.69	1.17	.0000	.45	1,183
Average,	21,700	56	54	-	-	.26	0.7239	.0358	10.63	2.71	.0005	.41	1,700

Septic Sewage and its Purification.

During the year 1903 three septic tanks have been operated at the station.

Septic Tank A, first put into operation during the latter part of 1897, had, at the end of 1903, been in operation a little more than six years. This is a wooden tank having a capacity of 225 gallons, and 250 gallons of sewage are admitted to it each twenty-four hours. At the end of 1902 about

33 per cent. of the capacity of the tank was filled with sludge and scum, and at the end of 1903 this accumulation had somewhat increased, and during the first few months of 1904 has increased rapidly, owing, apparently, to the fact that a stronger and fresher sewage was being pumped during these months than for several years past. Applying 250 gallons per day would, if the entire capacity of the tank were used, allow the sewage twenty-one and one-half hours in passing through the tank. As a matter of fact, with 33 per cent. of the capacity filled with sludge, etc., the sewage passes through much more quickly than this, or in about fourteen hours.

The following tables show the average analyses of the sewage entering and the effluent from this tank during the year, together with the determinations of solids in the applied sewage and effluent: —

Sewage for Septic Tank A.

[Parts per 100,000.]

1903.	Temperature. Deg. F.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. In Solution.	Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January,	37	2.85	.61	.27	6.03	3.77	2,260,000
February,	54	2.20	.45	.25	5.19	4.32	1,578,000
March,	56	2.45	.37	.19	5.76	3.27	1,466,000
April,	59	3.70	.47	.20	9.13	3.87	1,573,000
May,	64	3.93	.51	.23	9.68	3.47	2,538,000
June,	69	3.42	.40	.19	10.33	3.22	1,540,000
July,	72	3.93	.51	.23	13.39	3.64	1,713,000
August,	71	3.86	.59	.22	11.04	3.90	2,448,000
September,	69	4.05	.52	.24	16.61	3.84	2,435,000
October,	57	3.95	.65	.30	12.50	5.82	3,014,000
November,	56	5.24	.75	.36	11.32	5.26	2,838,000
December,	60	5.48	.54	.29	10.62	4.18	1,906,000
Average,	60	3.76	.53	.25	10.13	4.05	2,066,900

Septic Sewage. — Effluent of Tank A.

January,	46	1.92	.27	.16	3.91	2.12	1,041,800
February,	52	3.08	.36	.29	6.46	3.50	639,200
March,	55	3.02	.28	.17	4.87	2.01	491,000
April,	61	3.50	.25	.16	8.64	2.49	511,900
May,	70	4.30	.29	.20	9.71	2.64	669,800
June,	64	3.45	.31	.19	10.38	2.48	1,062,500
July,	73	4.14	.33	.22	14.13	2.48	1,177,000
August,	69	4.15	.38	.25	11.41	2.84	1,368,400
September,	68	4.10	.34	.22	13.68	2.49	1,692,000
October,	59	4.43	.40	.24	12.93	4.52	2,523,000
November,	52	4.98	.47	.26	12.03	3.52	1,617,000
December,	36	4.52	.48	.32	10.72	4.05	1,513,000
Average,	60	3.80	.35	.22	9.91	2.93	1,183,900

Solids in Sewage entering and Effluent of Septic Tank A.

Sewage entering.

[Parts per 100,000.]

1903.	Unfiltered.			Filtered.			Suspended.		
	Total.	Loss.	Fixed.	Total.	Loss.	Fixed.	Total.	Loss.	Fixed.
January,	54.6	25.3	29.3	35.2	13.8	21.4	19.4	11.5	7.9
February,	50.1	28.6	21.5	33.9	15.6	18.3	16.2	13.0	3.2
March,	54.3	25.9	28.4	34.3	13.8	20.5	20.0	12.1	7.9
April,	64.5	32.4	32.1	44.5	16.1	28.4	20.0	16.3	3.7
May,	62.5	29.1	33.4	43.7	15.3	28.4	18.8	13.8	5.0
June,	66.3	27.8	38.5	49.6	18.9	30.7	16.7	8.9	7.8
July,	74.8	32.3	42.5	52.0	15.6	36.4	22.8	16.7	6.1
August,	70.2	31.9	38.3	52.8	18.9	33.9	17.4	13.0	4.4
September,	77.2	32.3	44.9	63.8	21.3	42.5	13.4	11.0	2.4
October,	84.7	37.3	47.4	57.0	20.8	36.2	27.7	16.5	11.2
November,	72.0	35.8	36.2	48.7	17.4	31.3	23.3	18.4	4.9
December,	62.5	28.9	33.6	50.4	20.9	29.5	12.1	8.0	4.1
Average,	66.1	30.6	35.5	47.2	17.4	29.8	18.9	13.2	5.7

Effluent.

1903.	Unfiltered Total.	Unfiltered Loss.	Unfiltered Fixed.	Filtered Total.	Filtered Loss.	Filtered Fixed.	Suspended Total.	Suspended Loss.	Suspended Fixed.
January,	38.8	17.5	21.3	30.5	11.9	18.6	8.3	6.6	2.7
February,	47.3	22.3	25.0	38.7	15.4	23.3	8.6	6.9	1.7
March,	41.1	18.7	22.4	35.5	15.1	20.4	5.6	3.6	2.0
April,	52.5	24.7	27.8	42.5	15.8	26.7	10.0	11.9	1.1
May,	47.2	17.4	29.8	40.7	13.5	27.2	6.5	3.9	2.6
June,	52.5	18.3	34.2	46.5	15.4	31.1	6.0	2.9	3.1
July,	57.4	19.5	37.9	51.2	14.3	36.9	6.2	5.2	1.1
August,	57.3	19.3	38.0	50.9	14.5	36.4	6.4	3.8	1.6
September,	59.2	20.6	38.6	54.5	17.3	37.2	4.7	3.3	1.4
October,	64.5	24.7	39.8	50.4	17.5	32.9	14.1	7.2	6.9
November,	62.4	26.6	35.8	55.3	21.2	34.1	7.1	5.4	1.7
December,	61.6	28.8	32.8	57.2	21.2	36.0	4.4	7.6	-
Average,	53.5	21.5	32.0	46.2	16.1	30.1	7.3	5.4	2.4

These tables show that 19 per cent. of the solid matters in the entering sewage were retained in the tank, and that the solids of the effluent of the tank lost 70 per cent. as much matter upon ignition as the entering sewage. The total matters in suspension in the entering sewage were 18.1 parts per 100,000 and in the effluent 7.3 per 100,000, these figures showing a reduc-

tion of 60 per cent. as the sewage passes through the tank. The table of analyses shows that the albuminoid ammonia in the effluent was only 34 per cent. less than in the entering sewage, and that the oxygen consumed in the effluent was only 28 per cent. less than in the applied sewage during the year. These results are the poorest obtained during the operation of this tank, and are probably largely due to the loss of capacity of the tank, owing to accumulation of sludge.

Septic Tank D.

During 1900–01 an experiment was made in regard to the treatment of concentrated sewage or sludge in septic tanks, the motive for the experiment being to learn, if possible, how large a portion of sludge from settled sewage could be destroyed in this way; it being thought that if a considerable percentage could be so destroyed, septic tanks for the treatment of sludge only could be operated, thus doing away with the necessity of large tanks for the treatment of the entire flow of sewage at a filtration area wherever it was deemed desirable to adopt the septic tank treatment. The result of this experiment has been given in previous reports. Briefly, it was found that while a considerable volume of organic matter could be destroyed in this manner, still there was considerable difficulty in purifying the effluent of this tank both upon intermittent and contact filters without thorough preliminary aeration.

An investigation of a somewhat similar nature was begun in 1903. In this experiment, however, the object was not so much to obtain further data in regard to the destruction of sludge, but rather to learn the effect upon subsequent purification of prolonged treatment of sewage in a septic tank. For this purpose a tank of a capacity of about 300 gallons was constructed and divided into five compartments. Enough sewage was passed in each day to fill one of these compartments, and in this way the sewage has been in a general way about five days in passing through this tank. The tank was so arranged that the sewage could be drawn from each compartment, — that is, when it was one, two, three, four or five days old, — and sand filters were put into operation receiving sewage from these compartments. (See pages 254, 255.) At the end of the year 16 per cent. of the first compartment was filled with sludge, 10 per cent. of the second compartment, and 3.5 per cent. of each of the remaining compartments.

The average analyses of the sewage entering and of the effluent of different compartments of this tank are shown in the following set of tables: —

Sewage for Septic Tank D.

[Parts per 100,000.]

1903.	Temperature. Deg. F.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. In Solution.	Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
April,	54	3.97	.50	.29	10.40	3.28	1,543,000
May,	61	3.70	.42	.22	10.38	2.93	1,867,000
June,	61	4.30	.47	.28	13.66	3.20	2,189,000
July,	74	3.75	.49	.32	15.14	3.06	1,805,000
August,	65	2.70	.35	.18	12.09	3.76	2,095,000
September,	68	4.30	.48	.25	17.57	3.56	2,580,000
October,	59	4.90	.48	.34	18.53	3.89	2,255,000
November,	50	3.50	.44	.28	9.17	6.20	-
December,	48	5.90	.91	.37	12.48	6.17	172,300
Average,	60	4.11	.50	.28	13.27	4.01	1,807,000

Effluent of First Compartment.— D-1.

1903.	Temperature. Deg. F.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. In Solution.	Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
April,	56	3.85	.36	.23	10.66	2.96	490,000
May,	59	3.90	.30	.21	11.20	2.83	1,290,000
June,	61	4.55	.36	.24	14.48	2.79	1,972,500
July,	69	4.18	.33	.26	15.46	2.62	1,263,000
August,	66	3.50	.35	.20	12.78	2.96	1,057,500
September,	62	4.65	.34	.22	14.36	2.80	1,425,000
October,	57	5.20	.36	.22	18.89	3.36	1,500,000
November,	49	4.70	.47	.28	12.93	4.15	1,100,000
December,	45	4.93	.48	.34	12.06	3.77	90,300
Average,	58	4.38	.37	.24	13.65	3.14	1,132,000

Effluent of Second Compartment.— D-2.

1903.	Temperature. Deg. F.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. In Solution.	Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
April,	56	3.65	.27	.17	10.50	2.92	490,000
May,	58	3.80	.29	.22	11.04	2.56	1,050,000
June,	61	4.58	.33	.22	15.30	2.55	1,297,500
July,	69	4.53	.31	.23	14.99	2.34	842,500
August,	66	4.35	.25	.17	13.85	2.48	572,000
September,	62	5.05	.34	.18	14.30	2.34	1,135,000
October,	56	5.10	.29	.21	17.44	2.92	1,315,000
November,	48	5.10	.39	.30	14.82	3.46	660,000
December,	45	5.33	.46	.35	12.57	3.63	1,123,300
Average,	58	4.61	.33	.23	13.87	2.80	942,800

Effluent of Third Compartment. — *D-3.*

[Parts per 100,000.]

1903.	Temperature. Deg. F.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. In Solution.	Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
April,	56	3.80	.29	.21	10.98	2.82	720,000
May,	58	3.73	.30	.20	10.95	2.49	937,000
June,	61	4.48	.30	.20	14.18	2.62	1,070,000
July,	69	4.25	.28	.23	14.59	2.38	650,000
August,	66	4.30	.25	.18	13.59	2.36	306,300
September,	61	4.15	.27	.17	14.31	2.14	740,000
October,	56	5.15	.23	.20	15.96	2.54	745,000
November,	48	5.55	.37	.24	14.73	3.02	660,000
December,	45	5.67	.49	.36	12.34	3.56	1,206,700
Average,	58	4.56	.31	.22	13.51	2.66	781,700

Effluent of Fourth Compartment. — *D-4.*

April,	56	3.70	.22	.17	9.95	2.90	265,000
May,	58	3.63	.24	.20	10.75	2.43	674,000
June,	61	4.50	.25	.19	13.57	2.39	802,500
July,	69	4.28	.25	.18	14.54	2.30	475,000
August,	66	3.75	.24	.16	13.30	2.28	280,000
September,	61	3.90	.21	.16	14.18	2.01	380,000
October,	57	5.05	.25	.15	15.45	2.44	1,090,000
November,	48	5.35	.33	.23	14.49	3.00	350,000
December,	45	5.60	.41	.29	12.38	3.55	713,300
Average,	58	4.42	.27	.19	13.18	2.59	558,900

Outlet. — *D-5.*

April,	56	3.13	.41	.15	7.47	2.45	444,100
May,	58	3.57	.22	.14	10.36	2.29	533,000
June,	61	4.08	.23	.17	12.76	2.34	895,000
July,	69	4.05	.22	.17	13.41	2.19	376,000
August,	66	4.25	.21	.14	13.18	2.30	375,000
September,	61	4.25	.27	.14	13.88	2.04	465,000
October,	56	4.50	.26	.16	14.77	2.38	765,000
November,	48	5.30	.35	.23	13.88	2.66	500,000
December,	45	5.20	.40	.31	11.39	3.35	830,000
Average,	58	4.26	.29	.18	12.34	2.47	575,900

These tables show that there was an increase in the percentage of organic matter removed as the sewage passed from compartment to compartment, and also a reduction in the numbers of bacteria in each compartment with the exception of the last, the effluent from which contained a slightly greater number than the effluent of compartment No. 4.

Septic Tank E.

A third septic tank, Tank E, was put into operation April 14, 1903. The object in starting this experiment was to learn whether or no a sewage containing a large amount of mineral salts, such as would be produced by a municipality with a very hard water supply or where much hard ground water leaked into a sewerage system, would be affected differently by bacterial tank action than a sewage such as commonly pumped at Lawrence. Certain published results of the operation of septic tanks in places where the water supply is undoubtedly hard, as shown by analyses, seemed to indicate — although no statement had been made to that effect — that in such sewages a chemical precipitation occurred in the tank, owing to the passing out of solution of some of the mineral salts held in solution by the sewage when entering. In order to make this study a galvanized iron tank, having a capacity of 160 gallons, was used, this tank being 6 feet long, 20 inches wide and 24 inches deep. The sewage entering the tank had added to it before entering lime and magnesium salts in such amounts as to increase the hardness to something between 150 to 200 parts per 100,000. A typical hard water was selected as a basis, and calcium chloride, calcium carbonate and magnesium sulphate were added approximately in the proportion in which they were found in that water; 175 gallons of sewage were passed through this tank each day.

From the beginning of operation of the tank there was a very voluminous formation of gas. The effluent was a much darker color than from other septic tanks in operation at the station, and also had the very strong and disagreeable odor of hydrogen sulphide, the formation of this hydrogen sulphide undoubtedly being due to the decomposition of the large amount of sulphates introduced into the sewage. Some precipitation occurred in the tank and the effluent was generally somewhat clearer than from other tanks in operation. This phenomenon, however, was not as great as expected. The operation of the tank, however, has shown more or less clearly the reason that septic tanks in different localities produce different odors, this experiment indicating that it is, perhaps, not so much due to different bacterial actions or different organic matter, especially when the sewage is domestic sewage, but rather to the presence of sulphates in the water or sewage. The sludge accumulating in this tank was of an unusually offensive quality.

The following tables give the average analyses of the sewage entering and the effluent from this tank : —

Sewage for Septic Tank E.

[Parts per 100,000.]

1903.	Temperature. Deg. F.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. In Solution.	Chlorine.	Oxygen Consumed.	Hardness. Temporary.	Hardness. Permanent.	Hardness. Total.	Bacteria per Cubic Centimeter.
April,	66	4.40	.56	.28	11.68	4.64	24.0	138.0	162.0	200,000
May,	65	4.37	.55	.22	87.70	3.55	27.7	151.0	178.7	1,450,000
June,	64	4.27	.54	.25	96.97	3.67	27.9	164.8	192.7	2,046,700
July,	71	3.98	.48	.28	102.94	2.89	24.9	153.5	178.4	1,540,000
August,	69	3.95	.55	.20	101.28	3.72	26.6	171.1	197.7	2,037,500
September,	72	3.15	.60	.22	105.30	3.52	24.0	167.0	191.0	1,915,000
October,	62	4.63	.75	.24	109.60	4.66	28.4	172.0	200.4	1,947,000
Average,	67	4.11	.58	.23	87.92	3.81	26.2	159.6	185.8	1,590,900

Septic Sewage.— Tank E.

1903.	Temperature. Deg. F.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. In Solution.	Chlorine.	Oxygen Consumed.	Hardness. Temporary.	Hardness. Permanent.	Hardness. Total.	Bacteria per Cubic Centimeter.
April,	56	3.13	.28	.15	52.13	2.12	19.9	146.3	166.2	514,800
May,	62	3.50	.26	.13	75.03	2.36	21.3	130.7	152.0	610,800
June,	61	3.83	.27	.20	82.23	2.59	22.2	138.2	160.4	1,466,700
July,	74	4.22	.28	.18	92.88	4.40	29.4	129.5	158.9	628,000
August,	70	4.23	.31	.17	105.28	5.37	33.9	162.6	196.5	647,500
September,	73	4.50	.29	.19	90.70	4.85	35.0	159.0	194.0	540,000
October,	64	4.70	.37	.21	108.83	5.03	32.5	175.0	207.5	890,000
Average,	66	4.02	.29	.18	86.73	3.82	27.7	148.8	176.5	756,800

Purification of Septic Sewage.

During 1903 nine filters have been in operation to which the effluents from septic tanks have been applied. All of these filters with one exception were intermittent sand filters.

Filter No. 100, $\frac{1}{20000}$ of an Acre in Area.

Filter No. 100, containing 5 feet in depth of sand of an effective size of 0.23 millimeter, had at the end of 1903 received septic sewage from Tank A for a period of six years. The rate of 300,000 gallons per acre daily at first maintained had been decreased slightly, and during 1903 was 270,300 gallons per acre daily. During November the filter showed evidence of being overworked and poor purification was obtained. An examination of the sand showed an accumulation of clogging material to such an extent that the rate was decreased and periods of rest allowed.

Effluent of Filter No. 100.

[Parts per 100,000.]

1903.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. — Sewage.	Temperature. Deg. F. — Effluent.	Length of Time Sewage Remained on Surface. — Minutes.	Appearance. — Turbidity.	Appearance. — Color.	Ammonia. — Free.	Ammonia. — Albuminoid. — Total.	Ammonia. — Albuminoid. — In Solution.	Chlorine.	Nitrogen as — Nitrates.	Nitrogen as — Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Jan., .	300,000	46	60	28m.	Slight.	0.34	0.3170	.0655	.0505	6.40	2.59	.0076	0.65	28,100
Feb., .	287,500	52	60	20m.	Slight.	0.36	0.2550	.0680	.0585	6.25	3.38	.0053	0.72	25,500
Mar., .	288,500	55	60	27m.	Slight.	0.30	0.4155	.0620	.0500	5.94	3.08	.0065	0.62	46,400
Apr., .	265,400	61	60	33m.	Slight.	0.23	0.1800	.0507	.0453	5.16	3.45	.0012	0.52	38,900
May, .	276,900	70	61	18m.	Slight.	0.24	0.3300	.0730	.0580	9.90	4.49	.0010	0.64	24,900
June, .	288,500	64	64	20m.	Slight.	0.34	0.3120	.0840	.0520	11.01	4.99	.0093	0.82	73,800
July, .	277,800	73	71	13m.	Slight.	0.40	0.2733	.0807	.0660	15.16	5.04	.0022	0.66	111,700
Aug., .	300,000	69	67	25m.	Slight.	0.39	0.2575	.0740	.0630	12.47	4.49	.0053	0.72	148,500
Sept., .	300,000	68	65	22m.	Slight.	0.37	0.2813	.0707	.0560	11.71	5.80	.0067	0.63	94,700
Oct., .	300,000	59	53	40m.	Slight.	0.64	0.5900	.0770	.0710	10.68	2.51	.0056	0.77	114,000
Nov.,*	168,000	52	55	-	Slight.	1.14	2.6600	.2550	.2450	13.25	0.71	.0120	3.37	125,000
Dec., .	88,900	57	57	-	Decided.	1.30	1.2000	.0820	-	9.70	1.04	.0140	1.14	62,500
Av.,	270,300	61	62	-	-	0.45	0.4011	.0716	.0570	9.49	3.71	.0059	0.72	69,900

* Not included in average.

Filter No. 103, $\frac{1}{20000}$ of an Acre in Area.

Filter No. 103 is a coke contact filter 5 feet in depth, the coke in this filter being of such a size that all will pass through a sieve with a ½-inch mesh and practically none through a sieve with a ⅛-inch mesh; and at the end of 1903 it had been in operation six years. This filter was operated at an average rate of 788,500 gallons per acre daily during 1903, and gave a somewhat better effluent than during the previous year.

Effluent of Filter No. 103.

[Parts per 100,000.]

1903.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. — Sewage.	Temperature. Deg. F. — Effluent.	Appearance. — Turbidity.	Appearance. — Color.	Ammonia. — Free.	Ammonia. — Albuminoid. — Total.	Ammonia. — Albuminoid. — In Solution.	Chlorine.	Nitrogen as — Nitrates.	Nitrogen as — Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January, .	1,244,400	46	59	Decided.	0.43	0.3385	.1010	.0800	5.29	1.09	.0074	0.84	633,900
February, .	735,000	52	58	Decided.	0.54	0.3150	.1300	.0847	5.34	0.97	.0079	1.11	208,000
March, .	652,900	55	59	Decided.	0.39	0.7433	.1093	.0727	7.51	1.00	.0100	0.98	249,300
April, .	849,200	61	59	Slight.	0.37	0.2800	.0900	.0700	5.91	1.24	.0100	0.78	163,300
May, .	695,400	70	61	Slight.	0.29	0.6875	.1200	.0870	9.63	1.97	.0075	0.97	241,300
June, .	477,000	64	64	Slight.	0.86	1.0538	.1010	.1010	12.10	1.03	.0116	0.80	181,500
July, .	711,100	73	71	Slight.	0.68	0.6733	.1280	.1193	14.66	1.22	.0034	0.68	287,200
August, .	912,500	69	68	Decided.	0.51	0.5500	.1100	.0920	12.03	2.09	.0075	0.86	290,000
September, .	740,400	68	66	Decided.	0.43	0.5400	.1107	.0887	10.86	1.38	.0061	0.96	377,000
October, .	747,800	59	53	Decided.	0.66	0.4750	.1610	.1230	10.75	1.39	.0027	1.91	505,000
November, .	979,600	52	54	Decided.	0.58	0.4400	.1540	.1450	11.59	0.53	.0016	1.23	800,000
December, .	717,000	56	56	Great.	1.10	1.1300	.1740	.1180	9.18	0.95	.0026	1.76	445,500
Average,	788,500	60	61	-	0.57	0.6022	.1241	.0984	9.57	1.24	.0065	1.07	365,200

Solids in Effluent of Filter No. 103.

[Parts per 100,000.]

1903.	Unfiltered.			Filtered.			Suspended.		
	Total.	Loss.	Fixed.	Total.	Loss.	Fixed.	Total.	Loss.	Fixed.
January,	29.7	8.7	21.0	28.5	7.7	20.8	1.2	1.0	0.2
February,	29.0	9.8	19.2	27.7	8.8	18.9	1.3	1.0	0.3
March,	29.3	9.6	19.7	27.2	7.8	19.4	2.1	1.8	0.3
April,	33.0	11.5	21.5	30.9	10.1	20.8	2.1	1.4	0.7
May,	44.7	13.5	31.2	43.6	12.5	31.1	1.1	1.0	0.1
June,	43.1	7.9	35.2	42.6	7.8	34.8	0.5	0.1	0.4
July,	51.8	9.8	42.0	51.8	9.7	42.1	0.0	0.1	-
August,	50.6	9.1	41.5	50.6	9.1	41.5	0.0	0.0	0.0
September,	46.2	9.2	37.0	44.8	8.4	36.4	1.4	0.8	0.6
October,	51.2	14.0	37.2	49.2	13.1	36.1	2.0	0.9	1.1
November,	49.6	11.0	38.6	46.0	11.0	35.0	3.6	0.0	3.6
December,	48.0	15.0	33.0	42.6	11.8	30.8	5.4	3.2	2.2
Average,	42.2	10.8	31.4	40.5	9.8	30.7	1.7	1.0	0.9

Filters Nos. 209, 210, 211, 212 and 213.

These five sand filters, only 6 inches in diameter and containing 4 feet in depth of sand of an effective size of 0.27 millimeter, were put into operation early in May, and received the effluents from the various compartments of Septic Tank D: Filter No. 209 receiving the effluent from the first compartment; Filter No. 210, from the second compartment, etc. The average analyses of the first and last of these filters follow. The object of their operation was, as already stated in this report, to study the purification of sewage after different periods in a septic tank. The results showed that with the Lawrence sewage the period that the sewage remains in the tank has, with a tank arranged as Septic Tank D, little influence on subsequent purification by sand filtration. The sewage from Septic Tank B, discussed in previous reports, was difficult to purify, but in this tank the entering sewage was very strong, and the entire volume of sewage remained above the putrefying sludge in the tank and was saturated with bodies inimical to nitrification.

Effluent of Filter No. 209.

[Parts per 100,000.]

1903.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
May, . .	100,000	59	59	V. slight.	.21	1.5975	.0390	11.17	0.13	.0228	.42	33,300
June, . .	95,200	61	61	None.	.23	2.1500	.0380	17.04	3.00	.1518	.32	4,700
July, . .	95,500	69	69	V. slight.	.23	0.1180	.0315	15.16	3.80	.0075	.34	3,600
August, . .	100,000	66	66	V. slight.	.24	0.0132	.0400	12.31	2.74	.0023	.41	8,600
September, .	100,000	62	62	V. slight.	.23	0.0104	.0354	15.17	2.92	.0019	.39	9,500
October, . .	100,000	57	57	V. slight.	.25	0.0348	.0343	17.20	3.55	.0045	.40	7,500
November, .	100,000	49	49	V. slight.	.35	0.8145	.0590	12.70	4.75	.0050	.59	4,700
December, .	100,000	65	65	V. slight.	.36	0.1655	.0520	10.11	3.62	.0225	.67	6,450
Average, .	98,800	61	61	-	.26	0.6130	.0411	13.86	3.06	.0273	.44	9,800

Effluent of Filter No. 213.

May, . .	100,000	58	58	V. slight.	.16	1.1250	.0370	10.38	0.16	.0505	.34	36,100
June, . .	95,200	61	61	None.	.18	0.6350	.0276	12.81	3.12	.1575	.24	5,600
July, . .	95,500	69	69	None.	.20	0.0102	.0305	14.66	3.26	.0073	.28	1,950
August, . .	100,000	66	66	None.	.19	0.0069	.0289	13.23	3.35	.0021	.32	3,500
September, .	100,000	61	62	None.	.23	0.0142	.0328	13.78	3.35	.0040	.35	19,900
October, . .	100,000	56	57	None.	.23	0.0072	.0250	14.25	3.80	.0021	.34	4,100
November, .	100,000	48	48	None.	.29	0.3895	.0340	14.10	4.21	.0060	.44	3,600
December, .	100,000	65	65	None.	.35	0.3525	.0300	10.75	3.01	.0200	.53	7,050
Average, .	98,800	60	61	-	.23	0.3175	.0307	12.93	3.03	.0314	.35	10,200

Filter No. 223.

For three months, beginning August 1, a filter 6 inches in diameter and containing 5 feet in depth of sand of an effective size of 0.27 millimeter was in operation, receiving the effluent from Septic Tank E. This sewage was purified without difficulty, as shown by the following table: —

Effluent of Filter No. 223.

[Parts per 100,000.]

1903.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
August, . .	145,200	70	68	None.	.17	.2960	.0280	84.70	3.02	.2600	.32	35,000
September, .	150,000	73	68	None.	.25	.0093	.0357	87.50	3.28	.0016	.39	25,000
October, . .	150,000	64	59	V. slight.	.20	.0346	.0406	10.38	3.14	.0014	.40	11,000
Average, .	148,400	69	65	-	.21	.1133	.0348	60.86	3.15	.0877	.37	23,700

Comparison of Purification of Station Sewage and Sewage from Septic Tank A.

Filters Nos. 202 and 203, $\frac{1}{8000}$ of an Acre in Area.

Two sand filters of equal depth of sand of an effective size of 0.27 millimeter have been in operation during the year, one of which, No. 202, has received the sewage from Septic Tank A, and the other, No. 203, regular station sewage. They have been operated at low and equal rates, and the resulting purification has been practically equal, although the filter receiving station sewage has given slightly the better result.

Effluent of Filter No. 202.

[Parts per 100,000.]

1903.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
February, .	48,000	47	67	V. slight.	.34	.1867	.0100	5.40	0.17	.0040	.29	7,700
March, . .	48,100	42	65	None.	.17	.1708	.0113	6.93	3.74	.0748	.16	1,335
April, . .	44,200	52	65	None.	.22	.0140	.0060	6.92	3.66	.0024	.23	5,800
May, . .	52,000	62	67	None.	.18	.0192	.0145	10.83	4.00	.0020	.17	2,048
June, . .	48,000	63	65	None.	.21	.0195	.0117	11.27	4.31	.0012	.15	300
July, . .	48,100	70	74	None.	.20	.0149	.0155	14.09	4.14	.0017	.13	125
August, . .	50,000	67	68	None.	.15	.0095	.0126	13.59	3.57	.0011	.14	473
September, .	50,000	67	68	None.	.15	.0124	.0117	14.67	4.14	.0012	.16	70
October, . .	80,000	56	59	None.	.18	.0280	.0124	13.63	4.80	.0014	.14	175
November, .	80,000	52	60	V. slight.	.23	.2450	.0100	12.50	5.37	.0052	.24	140
December, .	80,000	65	65	V. slight.	.17	.0124	.0186	10.42	5.02	.0320	.16	12,600
Average, .	51,100	59	60	-	.20	.0666	.0122	10.93	3.90	.0115	.18	2,800

Effluent of Filter No. 203.

[Parts per 100,000.]

1903.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
February, .	50,000	52	67	None.	.20	.2940	.0187	5.36	0.11	.0007	.35	3,600
March, . .	48,100	55	65	None.	.13	.4330	.0150	7.26	2.12	.0861	.25	1,500
April, . .	44,200	61	65	None.	.08	.0060	.0060	5.82	3.32	.0004	.14	1,500
May, . .	52,000	70	67	None.	.07	.0057	.0120	10.46	4.07	.0009	.14	417
June, . .	48,000	64	65	None.	.09	.0031	.0130	11.87	4.25	.0001	.12	500
July, . .	48,100	73	74	None.	.10	.0027	.0137	14.01	3.93	.0002	.12	129
August, . .	50,000	69	68	None.	.08	.0012	.0121	15.43	3.75	.0000	.12	506
September, .	50,000	68	68	None.	.06	.0007	.0113	13.32	3.97	.0000	.14	38
October, . .	80,000	59	59	None.	.12	.0284	.0192	11.63	4.63	.0016	.20	1,500
November, .	80,000	52	60	None.	.16	.0016	.0154	11.95	5.17	.0000	.25	600
December, .	80,000	65	65	None.	.15	.0022	.0172	11.30	4.98	.0008	.21	7,400
Average, .	57,300	62	60	-	.11	.0708	.0139	10.76	3.67	.0082	.19	1,600

Contact Filters Nos. 103, 175, 176 and 221.

During 1903 four contact filters have been in operation, namely, Filters Nos. 103, 175, 176 and 221. Filter No. 103 was first put into operation on Feb. 28, 1898, and is constructed of 5 feet in depth of coke of such a size that all will pass through a sieve with a ½-inch mesh and practically none through a sieve with a ⅛-inch mesh. This filter had, at the end of 1903, been in operation six years, and has always received sewage from Septic Tank A (see table of analyses, page 253).

Filters Nos. 175 and 176, $\frac{1}{20000}$ of an Acre in Area.

Filters Nos. 175 and 176, put in operation June 3, 1901, were continued during 1903. Each filter is 5 feet in depth and is constructed of pieces of coke of such size that all will pass through a sieve having a 1-inch mesh, 75 per cent. through a sieve with a ½-inch mesh and practically none through a sieve with a ¼-inch mesh. Filter No. 175 has always received sewage that has first passed through a coke strainer, and Filter No. 176 has received the regular station sewage. Each of these filters is allowed to rest one week in each six. The following tables present the average analyses of the sewage applied to Filter No. 175, and the average analyses of the effluents of each filter and of the solid matters in the effluents of each. For the solids in the sewage applied to Filter No. 176 see page 222.

Effluent of Filter No. 175.

[Parts per 100,000.]

1903.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. Sewage.	Temperature. Deg. F. Effluent.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. In Solution.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January, .	693,300	47	64	Decided.	.60	0.6768	.1210	.0800	7.16	1.69	.0075	0.96	315,100
February, .	538,800	55	57	Decided.	.52	0.5507	.0773	.0598	5.55	1.75	.0032	0.84	186,200
March, .	539,200	59	61	Decided.	.43	0.6969	.0860	.0627	5.04	1.40	.0035	0.87	196,700
April, .	672,300	61	60	V. slight.	.41	0.8747	.0560	.0520	4.09	0.86	.0014	0.59	182,800
May, . .	552,100	69	64	Slight.	.25	0.5583	.0967	.0660	7.74	2.04	.0012	0.75	220,300
June, . .	541,000	65	63	Slight.	.31	0.4500	.1020	.0693	12.11	3.06	.0029	0.84	362,300
July, . .	533,300	75	71	Slight.	.30	0.8167	.1360	.0753	15.42	2.37	.0043	0.81	412,200
August, .	683,100	69	66	Decided.	.45	0.5100	.1240	.0820	12.59	3.53	.0028	0.94	367,500
September,	569,200	70	65	Decided.	.37	0.5300	.1293	.0727	10.67	2.34	.0063	0.88	455,000
October, .	571,100	55	56	Decided.	.80	0.6900	.1700	.1270	11.29	2.34	.0017	2.14	670,000
November,	691,200	56	57	Decided.	.65	0.7400	.2000	.1190	10.32	2.00	.0029	1.39	595,000
December,	570,400	56	60	Great.	.54	0.7500	.1860	.1240	9.70	2.89	.0110	1.46	898,500
Average,	596,300	61	62	-	.47	0.6486	.1237	.0824	9.31	2.27	.0041	1.04	401,000

Effluent of Filter No. 176.

January, .	622,200	45	58	Decided.	.50	0.7313	.1235	.0950	5.30	0.89	.0045	1.01	559,300
February, .	495,800	47	55	Great.	.70	0.9867	.1587	.1247	7.66	1.11	.0039	1.73	468,300
March, .	504,600	48	57	Decided.	.55	0.9000	.1440	.0953	6.51	1.09	.0083	1.21	367,300
April, .	672,300	52	58	Decided.	.47	0.8867	.1347	.0973	7.41	1.20	.0125	1.13	474,700
May, . .	550,000	62	64	Slight.	.35	0.6600	.0980	.0840	8.52	1.85	.0012	1.01	276,700
June, . .	517,300	63	63	Decided.	.49	3.4433	.1807	.1200	11.01	1.76	.0025	1.02	930,300
July, . .	548,300	70	71	Decided.	.52	1.1333	.1520	.1027	13.79	0.88	.0018	1.11	679,200
August, .	641,500	67	68	Decided.	.48	0.7100	.1620	.0840	12.55	1.30	.0035	1.13	580,300
September,	528,100	67	65	Decided.	.51	0.8300	.1787	.1387	11.60	1.12	.0038	1.25	1,017,000
October, .	562,800	56	55	Decided.	.90	0.7900	.2000	.1140	12.03	1.60	.0023	2.42	720,000
November,	744,000	52	56	Decided.	.73	0.4900	.1780	.1230	10.53	1.60	.0022	1.28	508,000
December,	570,400	56	56	Great.	.70	0.9700	.1920	.1440	9.02	1.90	.0085	1.75	593,200
Average,	579,800	57	60	-	.57	1.0443	.1543	.1102	9.66	1.36	.0046	1.34	597,900

Average Solids in Sewage applied to Strainer E.

[Parts per 100,000.]

1903.	Unfiltered.			Filtered.			In Suspension.		
	Total.	Loss on Ignition.	Fixed.	Total.	Loss on Ignition.	Fixed.	Total.	Loss on Ignition.	Fixed.
January, . .	52.1	26.4	25.7	52.6	12.8	39.8	-	13.6	-
February, . .	55.8	28.1	27.7	38.8	14.7	24.1	17.0	13.4	3.6
March, . . .	52.8	25.0	27.8	36.5	12.7	23.8	16.3	12.3	4.0
April, . . .	55.2	27.0	28.2	38.8	15.2	23.6	16.4	11.8	4.6
May, . . .	58.0	30.1	27.9	40.8	16.3	24.5	17.2	13.8	3.4
June, . . .	65.9	33.8	32.1	50.8	19.2	31.6	15.1	14.6	0.5
July, . . .	76.3	26.8	49.5	59.6	19.4	40.2	16.7	7.4	9.3
August, . . .	80.3	35.3	45.0	52.7	15.3	37.4	27.6	20.0	7.6
September, . .	74.0	30.6	43.4	61.0	21.2	39.8	13.0	9.4	3.6
October, . .	87.4	39.9	47.5	57.8	18.4	39.4	29.6	21.5	8.1
November, . .	62.6	31.0	31.6	52.0	22.2	29.8	10.6	8.8	1.8
December, . .	71.1	36.1	35.0	53.6	21.7	31.9	17.5	14.4	3.1
Average, . .	66.0	30.8	35.2	49.6	17.4	32.2	17.9	13.4	4.5

Average Solids in Effluent of Strainer E.

January, . .	38.9	16.0	22.9	32.1	10.7	21.4	6.8	5.3	1.5
February, . .	43.2	21.4	21.8	38.0	17.5	20.5	5.2	3.9	1.3
March, . . .	40.2	15.3	24.9	33.9	11.9	22.0	6.3	3.4	2.9
April, . . .	42.0	19.9	22.1	33.8	14.9	18.9	8.2	5.0	3.2
May, . . .	41.1	16.7	24.4	36.6	12.5	24.1	4.5	4.2	0.3
June, . . .	51.7	20.5	31.2	43.2	14.2	29.0	8.5	6.3	2.2
July, . . .	62.7	19.2	43.5	55.8	13.2	42.6	6.9	6.0	0.9
August, . . .	66.1	22.9	43.2	53.3	14.6	38.7	12.8	8.3	4.5
September, . .	59.9	20.9	39.0	52.7	15.9	36.8	7.2	5.0	2.2
October, . .	72.1	27.1	45.0	53.2	17.2	36.0	18.9	9.9	9.0
November, . .	61.3	31.2	30.1	46.6	17.9	28.7	14.7	13.3	1.4
December, . .	62.2	29.3	32.9	48.0	21.0	27.0	14.2	8.3	5.9
Average, . .	53.4	21.7	31.7	43.9	15.1	28.8	9.5	6.6	2.9

Solids in Effluent of Filter No. 175.

[Parts per 100,000.]

1903.	Unfiltered.			Filtered.			In Suspension.		
	Total.	Loss on Ignition.	Fixed.	Total.	Loss on Ignition.	Fixed.	Total.	Loss on Ignition.	Fixed.
January, . .	39.2	9.7	29.5	37.4	8.2	29.2	1.8	1.5	0.3
February, . .	34.7	12.4	22.3	33.3	11.4	21.9	1.4	1.0	0.4
March, . . .	33.5	10.9	22.6	30.7	9.1	21.6	2.8	1.8	1.0
April, . . .	30.5	10.5	20.0	29.8	10.5	19.3	0.7	0.0	0.7
May, . . .	44.8	13.7	31.1	43.2	12.9	30.3	1.6	0.8	0.8
June, . . .	55.1	13.4	41.7	54.2	12.7	41.5	0.9	0.7	0.2
July, . . .	58.9	11.6	47.3	58.4	11.3	47.1	0.5	0.3	0.2
August, . . .	76.2	26.7	49.5	59.4	11.6	47.8	16.8	15.1	1.7
September, . .	61.0	19.7	41.3	51.6	11.1	40.5	9.4	8.6	0.8
October, . . .	57.7	13.7	44.0	55.5	13.1	42.4	2.2	0.6	1.6
November, . .	50.4	14.6	35.8	48.3	12.4	35.9	1.1	2.2	-
December, . .	57.6	15.9	41.7	53.8	13.2	40.6	3.8	2.7	1.1
Average, . .	49.9	14.4	35.5	46.3	11.5	34.8	3.6	2.9	0.8

Solids in Effluent of Filter No. 176.

[Parts per 100,000.]

1903.	Unfiltered.			Filtered.			Suspended.		
	Total.	Loss.	Fixed.	Total.	Loss.	Fixed.	Total.	Loss.	Fixed.
January, ...	30.6	9.6	21.0	30.3	10.1	20.2	0.3	-	0.3
February, ...	40.0	14.1	25.9	37.3	12.2	25.1	2.7	1.9	0.8
March, ...	36.5	11.0	25.5	34.4	10.3	24.1	2.1	0.7	1.4
April, ...	39.4	12.5	26.9	37.9	11.7	26.2	1.5	0.8	0.7
May, ...	45.0	13.7	31.3	39.6	10.1	29.5	5.4	3.6	1.8
June, ...	52.9	14.5	38.4	49.7	12.3	37.4	3.2	2.2	1.0
July, ...	51.3	11.2	40.1	48.8	10.2	38.6	2.5	1.0	1.5
August, ...	53.5	11.6	41.9	52.4	11.0	41.4	1.1	0.6	0.5
September, . . .	50.9	14.5	36.4	48.4	12.4	36.0	2.5	2.1	0.4
October, ...	51.8	14.5	37.3	47.4	13.4	34.0	4.4	1.1	3.3
November, . . .	53.8	13.0	40.8	51.0	12.4	38.6	2.8	0.6	2.2
December, . . .	53.4	17.1	36.3	51.2	14.9	36.3	2.2	2.2	0.0
Average, . . .	46.6	13.1	33.5	44.0	11.8	32.2	2.6	1.5	1.3

Filter No. 221.

Filter No. 221 is $\frac{1}{5000}$ of an acre in area, and is constructed of 42 inches in depth of broken stone of such a grade that all the pieces pass an inch screen, 25 per cent. pass a $\frac{1}{2}$-inch screen and none through a $\frac{1}{4}$-inch screen. The underdrains of this filter are constructed of 6 inches in depth of cobble stones laid upon brick channels, this open construction of underdrains being intended to prevent clogging in this portion of the filter, such as occurred in a filter of broken stone, No. 137, operated during previous years. (See Report, 1902, page 194.) This filter was put into operation July 7, and has been operated at an average rate of 576,000 gallons per acre daily. Nitrification within it has been much less active than in contact filters of rough and porous material, as shown by the table of analyses.

Effluent of Filter No. 221.

[Parts per 100,000.]

1903.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
							Albuminoid.						
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Total.	In Solution.		Nitrates.	Nitrites.		
July, . .	572,700	70	67	Great.	.95	2.5067	.2347	.1433	12.29	.11	.0280	1.59	373,800
August, .	576,900	67	64	Decided.	.74	3.0500	.3240	.1820	10.79	.30	.0117	2.13	1,643,000
September,	570,800	67	64	Great.	.77	2.0250	.2440	.1660	11.38	.56	.0022	1.96	917,500
October, .	560,000	56	57	Great.	.70	1.9200	.2080	.1440	9.75	.37	.0020	2.64	1,050,000
November,	560,000	52	51	Great.	.80	2.6563	.3550	.2315	13.25	.11	.0000	3.36	1,330,000
December,	560,000	45	45	Great.	.90	2.6050	.3840	.2780	10.23	.04	.0000	3.20	1,470,000
Average,	566,700	59	58	-	.81	2.4605	.2916	.1908	11.28	.25	.0073	2.48	1,130,700

Loss of Open Space in Contact Filters.

In the last report figures were presented showing the loss of open space in contact filters during different periods of operation, and these determinations have been continued during 1903. At the end of the year Filter No. 103 had about 23 per cent. of open space, this being about 24 per cent. less than when it was first put into operation in the latter part of 1897; Filter No. 175 had about 35 per cent. of open space, a reduction of about 26 per cent. in two and one-half years; and Filter No. 176 had 35 per cent. of open space, a reduction of 26 per cent. in two and one-half years. These figures, compared with those given in the last report, show that there has been very little reduction in the open space in these filters during 1903. The various measurements made during the year have shown

a variation from time to time, but on the whole the filters have maintained a condition of equilibrium in this respect.

The total solids in the effluent of Filter No. 103 compared with the total solids of the sewage applied to this filter show a removal by the filter of about 66 per cent. of the combustible matter in the applied sewage. These solid determinations show clearly, also, the small amount of matters in suspension in the effluent of this filter; namely, only a total of 1.7 parts per 100,000. Somewhat poorer results in this respect were given by Filters Nos. 175 and 176, as would be expected, as these filters were of coarser material, and received in one instance untreated sewage, and in one sewage which had had a less efficient preliminary treatment than the sewage applied to Filter No. 103. A comparison of the condition of contact filters which have received raw sewage, and those which have received sewage that has passed through some treatment to remove matters in suspension, shows very clearly the necessity of a preliminary treatment in order that sludge and mineral matter may not accumulate in the upper layers of the filters; in other words, preliminary treatment of the sewage prolongs the life of the filter.

Intermittent Continuous Filtration.

Filters Nos. 135, 136, 189, 196 and 222.

During 1903 five filters have been in operation to which sewage has been applied almost continuously each day; these filters, however, as explained in previous reports, being constructed of such coarse materials that their surfaces are never covered with sewage, and the sewage is applied at such a rate that a large percentage of the open space of each filter always contains air.

Filters Nos. 135 and 136, $\frac{1}{20000}$ of an Acre in Area.

These two filters were first put into operation during 1899. They are each, at the present time, 11 feet 10 inches in depth, and are constructed of broken stone, all of which will pass through a screen with a 1-inch mesh, 40 per cent. through a screen with a $\frac{1}{2}$-inch mesh, and 4 per cent. through a screen with a $\frac{1}{4}$-inch mesh. The sewage is distributed over the surface of each by means of automatic tipping basins. Filter No. 135 continued to receive, during the year, the effluent of Coal Strainer E, and Filter No. 136, the effluent of Septic Tank A. These filters have been operated during the year at a higher rate than during previous years, the average rate of Filter No. 135 being 2,400,000 gallons per acre daily, and of Filter No. 136, 2,257,000 gallons per acre daily.

Nitrification was active in each filter during the year, although lower than during 1902, when they were operated at a lower rate. Their effluents have been almost invariably of a non-putrescible quality.

The tables of analyses of applied sewages and effluents follow, together with tables showing the average solid matter in their effluents: —

Average Yearly Analyses of Effluents of Septic Tank A and Strainer E.

[Parts per 100,000.]

1903.	Temperature. Deg. F.	Ammonia.			Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Free.	Albuminoid.				
			Total.	In Solution.			
Effluent of Septic Tank A,	60	3.50	.35	.22	9.91	2.93	1,188,900
Effluent of Strainer E, .	62	4.05	.39	.24	9.96	2.90	5,077,000

Effluent of Filter No. 135.

[Parts per 100,000.]

1903.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
							Albuminoid.						
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Total.	In Solution.		Nitrates.	Nitrites.		
January, .	2,314,800	49	51	V. slight	0.49	1.2338	.0755	.0715	5.82	1.55	.0118	0.72	30,000
February, .	1,902,900	55	50	V. slight.	0.56	1.4663	.0885	.0770	6.76	1.49	.0108	0.88	36,700
March, . .	1,871,600	59	53	Slight.	0.66	1.8375	.0930	.0795	5.64	1.44	.0115	0.91	46,100
April, . .	1,526,900	61	55	Slight.	0.64	2.1200	.1050	.0800	6.59	1.65	.0079	1.00	89,950
May, . .	2,483,100	69	60	Slight.	0.40	1.8625	.0750	.0710	8.22	0.91	.0095	0.82	15,000
June, . .	2,622,300	65	61	Slight.	0.70	1.6900	.0944	.0872	8.94	1.11	.0214	0.87	22,000
July, . .	2,437,800	75	69	V. slight	0.73	2.4600	.1107	.1073	13.58	0.72	.0088	0.80	68,900
August, .	2,632,300	69	65	V. slight.	0.69	1.4200	.1420	.0820	10.95	1.02	.0087	1.16	27,300
September, .	2,734,600	70	65	Slight.	0.59	1.3500	.2000	.1047	14.02	1.95	.0127	1.60	40,200
October, .	2,717,800	55	49	Decided.	0.75	1.1800	.1520	.1150	10.05	1.77	.0029	2.20	93,800
November, .	2,776,000	56	48	Slight.	0.84	1.3800	.2100	.1200	8.63	2.01	.0100	1.78	73,800
December, .	2,763,000	49	50	Slight.	0.95	1.2000	.4210	.1240	8.99	1.98	.0125	3.70	67,500
Average,	2,398,600	61	56	-	0.67	1.6000	.1473	.0933	9.02	1.47	.0107	1.37	51,100

Effluent of Filter No. 136.

January, .	2,327,100	46	51	V. slight.	0.47	0.4623	.1550	.0660	3.95	1.30	.0090	1.12	35,200
February, .	1,929,300	52	51	Slight.	0.65	1.0563	.2818	.0915	6.42	1.51	.0063	2.17	30,200
March, . .	1,962,600	55	54	Slight.	0.60	1.7350	.2268	.1150	5.86	2.06	.0078	1.05	56,200
April, . .	1,497,700	61	55	Slight.	0.58	1.5950	.1470	.0890	7.75	2.47	.0068	1.31	65,400
May, . .	2,080,000	70	60	Slight.	0.41	2.5600	.1460	.0840	10.14	1.60	.0108	1.37	31,000
June, . .	2,360,800	64	61	V. slight.	0.62	1.3540	.1696	.0692	10.39	1.88	.0075	1.31	26,600
July, . .	2,197,000	73	69	Slight.	0.58	1.4833	.2793	.0900	14.19	2.97	.0083	1.92	62,000
August, .	2,274,600	69	66	Slight.	0.69	1.6950	.2220	.0900	11.96	1.84	.0100	1.82	57,100
September, . .	2,490,500	68	65	Slight.	0.60	1.5967	.1560	.1020	11.27	1.84	.0107	1.41	88,000
October, .	2,761,500	59	49	Decided.	0.85	2.0850	.2180	.1420	13.94	2.19	.0032	2.73	161,600
November, .	2,691,200	52	49	Slight.	0.79	1.8500	.1880	.1210	13.39	1.59	.0110	1.66	58,900
December, .	2,514,800	49	50	Decided.	1.13	2.4050	.4040	.1730	9.25	1.66	.0155	3.06	100,000
Average,	2,257,300	60	57	-	0.66	1.6565	.2161	.1027	9.88	1.91	.0089	1.84	64,600

Average Solids in Effluent of Filter No. 135.

[Parts per 100,000.]

1903.	Unfiltered.			Filtered.			In Suspension.		
	Total.	Loss on Ignition.	Fixed.	Total.	Loss on Ignition.	Fixed.	Total.	Loss on Ignition.	Fixed.
January,	31.9	7.4	24.5	31.9	7.4	24.5	0.0	0.0	0.0
February,	32.6	9.7	22.9	31.6	8.7	22.9	1.0	1.0	0.0
March,	29.0	9.9	19.1	27.7	9.2	18.5	1.3	0.7	0.6
April,	40.3	12.6	27.7	37.5	11.2	26.3	2.8	1.4	1.4
May,	38.7	11.5	27.2	37.8	10.9	26.9	0.9	0.6	0.3
June,	38.8	9.5	29.3	38.8	9.5	29.3	0.0	0.0	0.0
July,	45.2	9.1	36.1	45.1	9.0	36.1	0.1	0.1	0.0
August,	45.0	10.6	34.4	41.0	8.2	32.8	4.0	2.4	1.6
September,	58.2	21.1	37.1	46.9	18.5	28.4	11.3	2.6	8.7
October,	47.4	13.5	33.9	44.2	12.2	32.0	3.2	1.3	1.9
November,	43.2	12.2	31.0	40.8	11.3	29.5	2.4	0.9	1.5
December,	66.5	27.8	38.7	41.8	13.8	28.0	24.7	14.0	10.7
Average,	43.1	12.9	30.2	38.8	10.8	28.0	4.3	2.1	2.2

Average Solids in Effluent of Filter No. 136.

January,	36.0	10.5	25.5	27.1	6.7	20.4	8.9	3.8	5.1
February,	43.1	17.2	25.9	32.7	10.3	22.4	10.4	6.9	3.5
March,	36.8	14.2	22.6	29.1	8.8	20.3	7.7	5.4	2.3
April,	51.4	20.7	30.7	46.2	17.6	28.6	5.2	3.1	2.1
May,	49.7	13.9	35.8	43.9	21.3	22.6	5.8	-	13.2
June,	51.7	13.8	37.9	41.7	7.8	33.9	10.0	6.0	4.0
July,	73.2	22.5	50.7	57.2	15.1	42.1	16.0	7.4	8.6
August,	56.6	15.7	40.9	45.9	10.4	35.5	10.7	5.3	5.4
September,	44.4	10.1	34.3	41.4	8.1	33.3	3.0	2.0	1.0
October,	56.5	16.5	40.0	52.2	15.1	37.1	4.3	1.4	2.9
November,	52.1	14.4	37.7	51.7	13.8	37.9	0.4	0.6	-
December,	59.5	25.1	34.4	45.0	15.6	29.4	14.5	9.5	5.0
Average,	50.9	16.2	34.7	42.8	12.5	30.3	8.1	4.7	4.8

Filter No. 189, $\frac{1}{20000}$ of an Acre in Area.

Filter No. 189 was first put into operation May 14, 1902, and was continued throughout 1903. This filter contains 10 feet in depth of broken brick, the pieces being about 2 inches in diameter, and has received regular

station sewage. The average rate of operation during 1903 was 2,543,000 gallons per acre daily. Nitrification was much less active in this filter during the year than in Filters Nos. 135 and 136, and the matter in suspension in its effluent was frequently of a putrescible quality, differing in this respect from the matter in the effluents of Filters Nos. 135 and 136.

The table of average analyses follows: —

Effluent of Filter No. 189.

[Parts per 100,000]

1903.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid. Total.	Albuminoid. In Solution.		Nitrates.	Nitrites.		
January, .	2,562,200	51	48	Decided.	0.95	2.7000	.3700	.1530	6.95	0.82	.0145	2.38	534,000
February, .	2,310,800	44	45	Decided.	1.04	1.9125	.5075	.1560	6.96	0.87	.0095	3.74	692,600
March, .	1,870,800	51	50	Decided.	0.93	2.3500	.5450	.1533	6.82	1.34	.0142	3.42	258,300
April, .	2,138,500	54	54	-	0.80	2.3725	.4550	.1205	9.02	0.48	.0120	2.74	291,250
May, . .	2,471,500	58	54	Decided	0.64	1.6250	.3625	.1520	10.66	1.35	.0325	2.33	205,500
June, . .	2,492,300	61	60	Slight.	0.80	2.1333	.4033	.1760	14.32	1.41	.0450	2.32	368,300
July, . .	2,571,100	70	69	Decided.	1.00	1.9625	.2950	.1370	11.75	0.99	.0178	2.10	170,000
August, .	2,783,100	67	66	Decided.	1.04	2.3000	.3100	.1100	7.21	0.90	.0320	2.33	155,000
September,	2,603,800	60	56	Decided.	0.95	1.8467	.2940	.1573	13.85	1.08	.0253	2.38	285,800
October, .	2,871,900	57	55	Decided.	1.10	1.8567	.2897	.1387	11.87	1.03	.0360	2.32	323,000
November, .	2,883,200	53	44	Decided.	1.04	2.3250	.4550	.2040	11.49	1.06	.0135	3.17	520,000
December, .	2,954,000	46	46	Decided.	1.02	3.5562	.3675	.1842	12.28	0.40	.0220	2.58	382,500
Average,	2,542,800	56	54	-	0.94	2.2450	.3879	.1535	10.27	0.98	.0229	2.65	348,800

Filter No. 196, $\frac{1}{5000}$ of an Acre in Area.

Filter No. 196 was put into operation during the last part of 1902 and continued during the first nine months of 1903. This filter was 64 inches deep and constructed as follows: at the bottom, 1 foot of field stones 6 to 8 inches in diameter; above this layer, 1 foot of similar stones 4 to 6 inches in diameter; then 1 foot of stones 2 to 4 inches in diameter; 1 foot 9 inches, $\frac{1}{2}$ to 2 inches in diameter; 3 inches of finer stone, and above the stones, 4 inches in depth of a mixture of buckwheat coal and coke.

The effluent of this filter during its period of operation was very poorly purified, being generally exceedingly turbid, with considerable odor and putrescible. The average rate for the year was 1,142,600 gallons per acre daily.

The table of analyses follows: —

Effluent of Filter No. 196.

[Parts per 100,000.]

1903.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
							Albuminoid.						
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Total.	In Solution.		Nitrates.	Nitrites.		
January, .	911,900	45	48	Decided.	0.63	2.2840	.2000	.1382	6.96	0.27	.0064	1.47	356,900
February, .	844,600	47	52	Decided.	0.81	2.2281	.3713	.1450	7.78	0.39	.0069	2.56	430,000
March, .	892,900	56	55	Great.	0.80	1.9580	.4782	.1198	5.14	0.68	.0140	3.16	418,600
April, . .	856,900	61	57	Decided.	0.52	2.3033	.1983	.0920	10.08	0.61	.0120	1.69	210,300
May, . .	1,335,000	64	60	Slight.	0.38	1.6633	.2750	.0760	5.41	0.56	.0180	1.48	130,000
June, . .	1,361,700	63	60	Decided.	1.07	2.8125	.3033	.1200	8.33	0.22	.0054	2.62	247,200
July, . .	1,362,400	73	69	Slight.	0.72	2.6125	.2750	.1332	13.63	0.78	.0404	1.74	132,800
August, .	1,388,300	69	69	Slight.	0.67	3.8750	.2550	.1080	12.45	0.79	.0425	1.88	137,800
September, .	1,329,800	70	65	Slight.	0.65	2.5520	.2776	.1212	15.89	1.22	.0360	1.91	143,700
Average,	1,142,600	61	59	-	0.69	2.4760	.2926	.1170	9.52	0.61	.0202	2.06	245,300

Filter No. 222 (Andover), $\frac{1}{200}$ of an Acre in Area.

This filter, located at the Andover sewage area, was put into operation July 13, 1903, and receives Andover sewage after it has passed a settling tank. The sewage is taken from the weir chamber at the end of the Andover settling tank by a 4-inch pipe, and this pipe extends 5 to 6 inches below the constant water level of the tank. A 4 to 2 inch bushing reduced the pipe to a 2-inch, through which the settled sewage flows to the filter.

The filter is 17.6 feet in diameter, or $\frac{1}{200}$ of an acre in area, has a mean depth of 8 feet and is constructed as follows: the original cypress tank used for this filter was 6 feet in depth only, and to allow a depth of 8 feet, the sides were built up with large field stones to a height of 2 feet; for collecting drains, 6-inch Akron drain pipes with open joints are laid across the diameters of the filter. These pipes extend to within 2 feet of the sides of the filter. Above and around these drain pipes are placed 13 inches of large field stones, some of which are nearly a foot in diameter. On these is placed a layer of 7 inches of small field stone, and above these 54 inches of broken stone, most of the pieces of which are more than 2½ inches in diameter, and on top of this, a layer of 22 inches of broken stone of a somewhat smaller grade. In three places, equally distant from each other, 4 feet down from the top of the sides of the filter are holes in which 6-inch Akron drain pipes are introduced. These pipes are slanted downward so that they extend about 4.5 feet below the surface, and were intended to supply air to the main body of the filter, but are probably unnecessary. The sewage was applied during the summer by means of a tipping basin, 12 feet in length, holding about twenty-five gallons of sewage.

On November 9, in preparation for the winter, the tipping basin was removed and a subsurface method of distribution installed, — a series of

pipes discharging into troughs laid upon fine crushed stone. All the valves and piping through which sewage passes to the filter were enclosed in order to protect them from the weather, and it has operated without difficulty during the cold winter of 1903–04, the rate of operation averaging for the year 1,405,000 gallons per acre daily.

Nitrification began in this filter almost as soon as started, and during September averaged 1.10 parts of nitrates per 100,000. The effluent of the filter, while high in free and albuminoid ammonia, has had very little odor and has generally been non-putrescible.

Tables of the sewage applied to and the effluent from this filter follow: —

Sewage for Filter No. 222, Andover.

[Parts per 100,000.]

1903.	Temperature. Deg. F.	Ammonia.			Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Free.	Albuminoid.				
			Total.	In Solution.			
July,	-	5.15	0.64	.47	8.45	3.40	-
August,	64	5.38	0.66	.39	5.88	4.10	2,180,000
September,	64	6.45	0.79	.44	11.33	4.56	3,400,000
October,	59	6.33	0.82	.46	8.67	4.22	2,110,000
November,	52	6.63	1.05	.67	8.00	5.83	3,350,000
December,	47	3.19	0.51	.33	3.80	3.52	1,255,000
Average,	57	5.52	0.74	.46	7.69	4.27	2,459,000

Effluent of Filter No. 222, Andover.

[Parts per 100,000.]

1903.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Dissolved Oxygen. (Per Cent of Saturation.)	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid. Total.	Albuminoid. In Solution.		Nitrates.	Nitrites.			
July,*	89,400	-	65	V. slight.	0.89	3.3967	.2773	.1980	7.44	0.33	.0947	1.33	-	-
Aug.,	1,369,300	64	64	V. slight.	0.92	3.3980	.3408	.1952	7.40	0.87	.1480	1.65	43.9	28,600
Sept.,	1,459,400	64	66	V. slight.	0.84	3.3125	.3830	.1655	7.62	1.10	.0825	1.66	50.3	533,000
Oct.,	1,498,600	59	60	V. slight.	0.84	3.5040	.3868	.1836	7.05	0.97	.0690	1.70	58.0	450,000
Nov.,	1,262,500	52	51	Slight.	1.05	4.7438	.7800	.4115	7.10	0.17	.0123	3.42	39.3	2,300,000
Dec.,	1,434,200	47	46	-	0.78	2.8270	.3902	.2366	3.81	0.11	.0094	2.45	39.7	945,000
Av.,	1,404,800	57	57	-	0.89	3.5571	.4562	.2385	6.60	0.64	.0642	2.18	46.2	851,300

* Started July 13 and operated at a low rate to hasten nitrification. Not included in average.

Discussion of Intermittent Continuous Filtration.

Up to the end of 1903 eight intermittent continuous filters have been operated at Lawrence if we include Filters Nos. 15 A and 16 B, which were operated on practically the same principle for several years, beginning in 1892. All of these filters have been constructed of comparatively smooth material. The operation of these filters has shown that with filters of material as fine as in Filters Nos. 135 and 136, and with depths of filtering material of ten feet, rates of 2,500,000 gallons per acre daily can generally be maintained and result in practically odorless and non-putrescible effluents. With coarser materials and with equal depths such rates cannot be maintained and produce effluents of a general non-putrescible nature. Shallower depths and with a graded material, considerable portions of which are coarse, such as exemplified by Filters Nos. 196 and 222, fail to give as satisfactory results. Beginning in January, 1904, filters of this kind, but constructed of different depths and grades of rough materials, have been put into operation for further investigations along this line.

Non-putrescibility of the Effluents of Contact and Intermittent Continuous Filters.

During 1903 a large number of incubation tests of the effluents of various representative rapid filters were made. None of the samples of effluent from Filters Nos. 135 and 136 (intermittent continuous) showed any signs of putrefaction while undergoing this test, as indicated by changed appearance and increased odor, and in no instance was the oxygen consumed increased at the end of the period of incubation. On the other hand, 63 per cent. of the samples from intermittent continuous Filter No. 189 putrefied while undergoing the test, and 75 per cent. showed an increase in oxygen consumed. This filter is constructed of much coarser material than Filters Nos. 135 and 136. Of the samples of effluents from coke contact filters, 14 per cent. showed slight putrefactive changes, as denoted by their increased odor at the end of the period of incubation, but none showed an increase in the amount of oxygen consumed.

Subsequent Treatment of Effluents of Intermittent Continuous Filters.

During the past three years much study has been given to the treatment of the effluents of intermittent continuous filters. The effluents of all these filters have at times much matter in suspension; for example, the effluent of Filter No. 135 during 1903 had 0.39 part of albuminoid ammonia, and of this, 0.24 part was in suspension. The effluents of the other filters show like results. When these filters are operating well, this highly oxidized, or residual innocuous suspended matter, settles readily, leaving a clear super-

natant effluent. Sedimentation then would seem to be the easiest way of separating this comparatively small amount of sediment from the large volume of effluent, and during 1903 the effluents of Filters Nos. 135 and 136 have been passed through a sedimentation tank, this tank being divided into compartments separated by an upright coke strainer. The following tables show the average analyses of the filter effluents entering this tank and the effluent of the tank. It will be seen that the effluent flowing away from the tank contained little organic nitrogen in suspension, and that the carbonaceous matters, as shown by the oxygen-consumed determinations, were very much reduced. The tables also show that nitrification occurred in the sedimentation tank, as shown also in the bottle experiments described in an article upon the "Stability of Effluents," in the report of the Board for 1901.

Average Effluent of Filters Nos. 135 and 136, May 1 to December 31, inclusive.

[Parts per 100,000.]

1903.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. Sewage.	Temperature. Deg. F. Effluent.	Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. In Solution.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
May 1 to Dec. 31, inclusive, .	2,533,600	63	58	.71	1.7232	.1992	.1051	11.12	1.69	.0101	1.80	62,000

Average Effluent of Filters Nos. 135 and 136 after Sedimentation.

[Parts per 100,000.]

1903.	Temperature. Deg. F.	Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. In Solution.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
May, ...	58	0.50	1.2000	.0840	.0800	9.00	1.47	.0400	0.95	18,500
June, ...	63	1.05	1.7267	.1040	–	10.77	1.81	.0333	0.85	67,300
July, ...	69	0.67	1.4067	.1040	.0920	13.33	1.58	.0200	0.81	1,627,500
August, ...	64	0.62	0.7900	.0880	.0740	9.89	2.25	.0210	0.83	546,800
September, ...	63	0.53	0.9700	.0870	.0755	13.64	2.67	.0100	0.78	573,000
October, ...	55	1.33	1.2700	.1900	.1130	13.75	2.09	.0145	1.62	127,000
November, ...	48	0.70	1.5325	.1310	.1110	13.08	3.13	.0250	0.99	17,500
December, ...	43	0.90	1.8000	.2360	.1607	10.62	3.15	.0277	1.64	48,700
Average, ...	58	0.79	1.3370	.1280	.1009	11.76	2.27	.0239	1.06	378,300

During eight months of the year the effluents of Filters No. 135 and 136 were, after passage through the sedimentation tank, passed to Filter No. 217, operated at a rate of 1,937,000 gallons per acre daily. This filter was constructed of 5 feet in depth of fine broken stone, and while some nitrification occurred in it, as shown by an increase of nitrates from 2.27 parts to 2.64 parts per 100,000, still the improvement was not sufficient to compensate for this secondary filtration.

Effluent of Filter No. 217, $\frac{1}{20000}$ of an Acre in Area.

[Parts per 100,000.]

1903.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature, Deg. F.		Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid. Total.	Albuminoid. In Solution.		Nitrates.	Nitrites.		
May,* .	2,000,000	-	-	-	-	-	-	-	-	-	-	-	-
June, . .	1,879,200	61	63	Slight.	.64	1.1250	.0820	.0780	9.46	2.19	.0300	0.72	41,500
July, . .	1,777,800	69	69	V. slight.	.61	1.6667	.0920	.0773	12.82	1.85	.0103	0.74	2,021,500
August, .	1,912,300	66	65	Slight.	.72	0.5700	.0820	.0640	9.98	2.26	.0115	1.03	497,000
September,	2,000,000	65	63	Slight.	.50	0.7200	.0890	.0710	14.27	2.85	.0078	0.84	1,052,000
October, .	1,925,900	49	55	Slight.	.85	0.9950	.1160	.1130	12.64	2.51	.0080	1.18	141,300
November,	2,000,000	49	48	Slight.	.68	1.0100	.1110	.0930	13.00	3.14	.0113	0.99	16,000
December,	2,000,000	44	45	-	.78	1.1633	.2037	.1293	10.79	3.72	.0120	1.75	48,200
Average,	1,936,900	58	58	-	.68	1.0357	.1108	.0894	11.85	2.64	.0130	1.04	545,300

* Ran five days only.

Filter No. 185, $\frac{1}{10000}$ of an Acre in Area.

This filter, containing 5 feet in depth of sand of an effective size of 0.23 millimeter, was in operation throughout 1902 and the first five months of 1903. It received during this period the effluents of Filters Nos. 135 and 136 at a rate exceeding 800,000 gallons per acre daily, and produced a well-purified effluent, as shown by the following table. The filter was operated without difficulty during this period, and when put out of operation was in good condition, although it was evident that operating at this rate, and receiving the effluents without preliminary removal of the suspended matter, would cause sand removal to become eventually necessary.

Effluent of Filter No. 185.

[Parts per 100,000.]

1903.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	996,800	51	49	3h. 27m.	V. slight	.38	0.6090	.0452	6.00	1.89	.0006	.52	24,600
February, .	872,200	51	47	5h. 22m.	V. slight.	.57	0.9345	.0700	6.59	1.43	.0007	.74	22,300
March, .	939,600	54	50	15h. 10m.	V. slight.	.43	0.6250	.0495	5.30	2.18	.0020	.61	19,600
April, . .	600,400	55	52	6h. 20m.	V. slight.	.38	0.8833	.0380	6.43	1.93	.0045	.52	15,800
May,* . .	933,200	60	59	24h.	V. slight.	-	1.1200	.0560	9.28	2.85	.0120	.74	10,800
Average,	868,400	54	51	10h. 52m.	-	.44	0.8344	.0517	6.72	2.06	.0040	.63	18,600

* Fourteen days.

Filter No. 224, $\frac{1}{20000}$ of an Acre in Area.

Filter No. 224, constructed of 54 inches in depth of sand of an effective size of 0.27 millimeter, was put into operation October 1, at a rate of 1,000,000 gallons per acre daily, receiving the mixed effluents of Filters Nos. 135 and 136 after removal by sedimentation of much of the suspended matters in these effluents. Upon December 4 the rate of operation was reduced to 600,000 gallons per acre daily, and it is intended to operate the filter at this rate for as long a period as possible without disturbing the sand to a greater depth than three inches, and to remove sand when the filter fails to take its daily dose and purify it satisfactorily.

Treatment of Waste Dye Liquors.

During 1903 considerable experimental work was carried on in studying the waste dye liquors from a woolen mill at Lawrence. The average amount of waste dye liquors discharged from this mill averaged about 62,000 gallons per day, and the dye-stuffs used were mainly aniline dyes and wood extracts. In collecting waste liquor for treatment, care was taken to collect only at such times as the dye tubs were being emptied, in order to avoid ordinary wash water, etc., as the volume of dye waste was only about 7.5 per cent. of the total amount of water used in washing and rinsing the cloth after dyeing. The liquors so collected were all highly colored, with but a small amount of fine suspended matter, although containing numerous pieces of detached yarn, etc. The colors varied greatly, and embraced nearly all shades from red to violet, but the predominating hue was a blue

black. The waste dye liquors had always the odor peculiar to the dye-house, caused largely by the presence of dextrine, with occasionally an alkaline, soapy odor. All wastes, without exception, were nearly neutral.

Intermittent filtration on sand and ashes, contact treatment in a coke bed, and intermittent continuous filtration through a filter of coarse stone were the methods first tried for disposing of the colored liquors. All these filters were small, none being over 6 inches in diameter.

Purification of Dye Liquor upon Filters of Various Types.

Filtration of Dye Liquor through Sand.

A small filter (No. 197), containing 5 feet of sand of an effective size of 0.26 millimeter, was flooded with dye liquor daily for six days in a week at a rate of 50,000 gallons per acre per day. The filter was started Dec. 3, 1902, and at this rate a clear, non-putrescible effluent was obtained. The removal of nitrogenous matter, as shown by albuminoid ammonia determinations, was 92.6 per cent.; of carbonaceous matters, as shown by oxygen-consumed determinations, was 93.5 per cent. A complete destruction of color was not attained, however, the effluent having a pale yellow color. From Dec. 3, 1902, to March 15, the filter was flooded eighty-three times, corresponding to 4,150,000 gallons of liquor on an area of one acre. No raking or other surface treatment of the filter was necessary. From March 15, 1903, to April 24, 1903, waste liquor could not be obtained and the filter was out of operation. From this last date to June 1, 1903, the filter was operated as before, and raked three inches deep once each week.

Treatment in a Contact Bed.

Filter No. 198 contained 5 feet of fine coke breeze. It was operated as a contact filter, with one filling each day, at a rate of 1,000,000 gallons per acre daily. There was a considerable reduction of the organic matters and a general clearing of the liquor. The bluish black color of the dye wastes was never completely removed, however, as was the case with sand filtration. The filter was started Dec. 3, 1902, and continued in operation until March 6, 1903. At this date the loss of open space was 15.4 per cent.

Intermittent Continuous Filtration.

Filter No. 199 contained 5 feet in depth of fine broken stone. It was flooded in such a way that dye liquor was applied in a small stream. The period of operation was twenty hours daily, and the rate was 540,450 gallons per acre daily. The color of the wastes applied was reduced even less than in the case of the contact bed. The filter was started Dec. 3, 1902. It was operated thirteen days in January, twenty-four days in February and five days in March. The experiment was finished March 6, 1903.

Analysis of the Applied Liquor and the Effluents of Filters Nos. 197, 198 and 199.

[Parts per 100,000.]

	Dye Liquor.	Effluent of Filter No. 197.	Effluent of Filter No. 198.	Effluent of Filter No. 199.
Color,	Blue-black.	Pale yellow.	-*	-*
Sediment,	Decided	0	Very slight	Very slight.
Odor,	Strong Dextrine.	0	Very slight.	Slight.
Free ammonia,	0.3285	0.0219	0.2413	0.2608
Total albuminoid ammonia,	0.2616	0.0193	0.0672	0.1034
Soluble albuminoid ammonia,	0.1548	-	-	-
Chlorine,	2.6800	2.6500	1.8900	1.5900
Nitrates and nitrites,	0.0000	0.2900	0.0400	0.0900
Oxygen consumed,	6.2800	0.4100	1.1400	1.9400
Alkalinity, normal acid per litre,	0.5500	-	-	-

* Much less than applied liquor but variable.

Treatment on Sand containing Marble Chips, — Filter No. 215.

Filter No. 215, started May 16, 1903, was constructed of 2½ feet in depth of sand of an effective size of 0.27 millimeter, on top of which was an 18-inch layer of a mixture of sand and marble chips. The rate of operation was 50,000 gallons per acre daily, and the results differed but little from those obtained with Filter No. 197.

Average Analysis of the Applied Liquor and Effluent of Filter No 215.

[Parts per 100,000.]

	Color.	Ammonia.		Oxygen Consumed.	Nitrates and Nitrites.
		Free.	Albuminoid.		
Applied dye liquor,	Blue-black.	.5800	.5520	6.00	-
Effluent, Filter No. 215,	V. slight yellow.	.0840	.0400	0.54	.12

The comparative percentage removal of organic matter by Filters Nos. 197, 198, 199 and 215 is shown in the following table: —

Filter No.	Percentage Removal of Organic Matter as shown by		Rate of Operation (Gallons per Acre Daily).
	Albuminoid Ammonia.	Oxygen Consumed.	
197,	92.6	93.5	50,000
198,	74.3	81.8	1,000,000
199,	60.8	67.5	540,000
215,	92.0	90.2	50,000

Chemical Treatment of Dye Liquor, followed by Sedimentation and Filtration through Sand, Ashes, etc.

The following series of experiments with various precipitants were made with dye liquors, these liquors being of the same character as those applied to the filters previously described.

Copperas. — Amounts from 5,000 to 30,000 pounds per 1,000,000 gallons. After one hour, good coagulation took place in all cases. The coagulated matter was coarse and settled readily, leaving an almost colorless supernatant liquid.

Lime. — Amounts 500, 1,000, 2,000, 3,000, 4,000, 5,000, 10,000, 20,000, 25,000 and 30,000 pounds per 1,000,000 gallons. Immediate precipitation took place with all amounts above 1,000 pounds. One thousand pounds of lime gave almost as good a result as did larger quantities of the precipitant. The supernatant liquids from lime treatment all had a brownish red color which varied in intensity inversely as the amount of precipitant used. This color, on standing, changed to a pale yellow.

Copperas and Lime. — Copperas was added first, then lime. Equal quantities of both precipitants were used. The amounts in pounds per 1,000,000 gallons were as follows: copperas, 500, 1,000, 1,500, 2,000, 2,500 and 3,000; lime, 500, 1,000, 1,500, 2,000, 2,500 and 3,000. From 2,000 pounds of the total coagulant upwards, excellent precipitation was obtained. Precipitation was fairly complete in forty-five minutes.

In a second experiment the proportions of lime and copperas were as follows: lime, 2,000, 2,000, 2,000, 1,000 and 1,000 pounds; copperas, 1,000, 750, 500, 1,500 and 2,000 pounds. In forty-five minutes good coagulation was visible. Other experiments were made with lime and copperas, and it was found that equal amounts of the two, with a total of 1,500 pounds, would give, in less than one hour, better coagulation and better color removal than an equivalent amount of either precipitant alone. The lime gave a brownish red color to the supernatant liquor, and this color was largely removed by the iron salt.

With the varying character of dye liquor, the amount of precipitants required for its treatment varied greatly, but the results of these experiments indicated that with a waste of the quality experimented with, copperas followed by lime in equal amounts, averaging about one-half a ton each for one million gallons of dye liquor, would give an excellent coagulation and a marked removal of color.

Experiments were made using ferric chloride with and without lime. It was found that excellent results could be depended upon using one-half a ton of lime and one-quarter to one-half a ton of ferric chloride. Ferric chloride proved to be more rapid in its action than copperas, but its high cost places it at a disadvantage.

Filtration after Chemical Precipitation.

Following these experiments it was decided to operate filters of sand and of ashes with the supernatant liquor from dye waste chemically treated, and two filters were put into operation; one containing sand, the other ashes from the combustion of bituminous coal.

Filter No. 205. — This filter was constructed of 4 feet in depth of sand of an effective size of 0.27 millimeter over the usual underdrains, and received supernatant dye liquor, chemically treated as described above, at the rate of 2,000,000 gallons per acre daily. The filter was flooded ten times in February, twenty times in March, not flooded from March 24 to April 24; it was flooded five times in April, twenty-seven times in May and nine times in June. The experiment was finished June 12. The filter was raked 3 inches deep each week, and the average analysis of its effluent for the period of operation was as follows: —

Effluent of Filter No. 205.

[Parts per 100,000.]

Color.	Ammonia.		Oxygen Consumed.	Nitrates and Nitrites.
	Free.	Albuminoid.		
Pale yellow,	.3733	.0931	1.54	.12

Filter No. 214. — This filter was constructed of 4 feet in depth of soft coal ashes screened through a ½-inch mesh sieve, the material passing the sieve being used. The filter received supernatant dye liquor, chemically treated, at a rate of 2,000,000 gallons per acre daily. The average analysis of its effluent was as follows: —

Effluent of Filter No. 214.

[Parts per 100,000.]

Color.	Ammonia.		Oxygen Consumed.	Nitrates and Nitrites.
	Free.	Albuminoid.		
Light yellow,	.5000	.1047	1.35	.08

Treatment of Sludge.

The sludge from the chemical treatment of dye wastes has averaged about 1.5 per cent. of the total volume of liquor treated. It can be readily cared for by intermittent filtration, as the following experiment shows.

Treatment of Sludge.

Filter No. 206. — Filter No. 206 was constructed of 2 feet in depth of soft coal ashes over 6 inches of underdrains. The filter received sludge from the several precipitations of dye liquor, described above, at the rate of 40,000 gallons to the acre. The filter was started Feb. 19, 1903, and up to July 1, 1903, was flooded seventy-three times. The liquor, in general, disappeared in twenty-four hours, so that the filter was ready to receive the next day's application. When the period of disappearance became unduly great, it was necessary to remove the sludge. This was done on March 9, April 30, May 8, June 2 and June 22. The effluent was always clear and contained a small amount of organic matter, as the following average analysis shows: —

Effluent of Filter No. 206.

[Parts per 100,000.]

Turbidity.	Color.	Ammonia.		Nitrates.	Nitrites.	Oxygen Consumed.
		Free.	Albuminoid.			
None,	.05	.0352	.0104	.17	.0001	.10

Analyses of two series of samples are given in the following table, showing the various stages of the purification of dye liquor by chemical precipitation, and sand filtration of the supernatant liquor: —

Analyses of Series.

[Parts per 100,000.]

	Dye Liquor.		Supernatant Liquor after Chemical Treatment.		Effluent of Filter No. 197.		Effluent of Filter No. 205.		Effluent of Filter No. 206.	
	Series I.	Series II.	Series I.	Series II.	Series I.	Series II.	Series I.	Series II.	Series I.	Series II.
Turbidity,	V. sl.	Great.	Slight.	V. sl.	None.	None.	None.	None.	None.	None.
Sediment,	Sl.	Dec.	Dec.	V. sl.	None.	None.	None.	None	None.	None.
Odor,	Sl.	Dec.	Slight.	Slight.	None.	None.	None.	None.	None.	None.
Color,	Dark blue.	dex. Black.	Red'sh brown.	Yellow green.	Pale yellow.	Light yellow.	V pale yellow.	Slight.	.09	.03
Free ammonia,	.3480	.1350	.6500	.2081	.0060	.0100	.6800	.0160	.0840	.0200
Albuminoid ammonia.	.1880	.3100	.1320	.1140	.0120	.0160	.0360	.0760	.0040	.0100
Oxygen consumed.	7.80	14.40	2.96	4.88	.37	.48	1.21	1.28	.10	.08
Chlorine,	8.83	-	-	-	-	-	4.68	-	4.42	-
Nitrates and nitrites.	-	-	-	-	.29	.08	.04	.01	.04	.06

Summary of Results.

These investigations show that dye liquor such as experimented with can be successfully treated. Sand filters at sewage rates will give excellent results and remove a very large percentage of the color, but require more surface raking than is generally necessary with sewage. Treatment of the liquor with lime, copperas or ferric chloride coagulates and carries down a large percentage of coloring and organic matter.

The effluents of the filters operated with the supernatant liquor from chemical treatment were clear, low in color, and with rates approximating 2,000,000 gallons per acre daily almost colorless effluents were obtained.

The experiments point conclusively to the advisability of experimentation in individual cases to determine the most efficient process to employ. It is hardly necessary to add that dye liquors can best be treated in concentrated form, that is, they should be removed to the point of disposal as undiluted with wash water as possible.

Treatment of Waste Liquors from the Manufacture of Coal and Water Gas.

Towards the end of 1903 experiments were begun upon the treatment of all the waste liquors from a large gas illuminating plant where both water and coal gas were made. These experiments are still incomplete, but so far have shown that there is little difficulty in improving these wastes very greatly. Heavy liquors full of carbonaceous matter, oils, tar, etc., can be so treated by chemicals, such as lime, copperas, etc., that most of this matter can be coagulated and will settle readily. Further than this, these liquors can be improved by rapid filtration through coke and sand. At the plant studied, filters have been operated and at times treated in the vicinity of 20,000 gallons per day, at rates of from 1,000,000 to 3,000,000 gallons per acre daily.

FILTRATION OF WATER.

The work upon water filtration during 1903 is recorded in the following pages.

Experimental sand filters receiving waters of varying degrees of pollution have been in operation, and studies of the chemical, bacterial and B. coli efficiencies of these filters have been made. The work of the Lawrence city filter has been followed and also the work of a filter at the station, operating at a high rate, with the aid of a coagulant, and receiving Merrimack River water.

Lawrence City Filter.

The Lawrence city filter is 2.5 acres in area, was constructed during 1893, and dividing walls separating the filter into three sections were built during 1902. Each year since the operation of this filter tables showing the average chemical and bacterial analyses of the Merrimack River water applied to it, and of samples of the effluent of the filter collected at different points upon the supply system, have been given in these reports, and the following tables give the results obtained during 1903: —

Merrimack River. — Intake of City Filter.

[Parts per 100,000.]

1903.	Temperature. Deg. F.	Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.	Bacteria per Cubic Centimeter.
		Turbidity.	Color.	Free.	Albuminoid. Total.	Albuminoid. Soluble.		Nitrates.	Nitrites.				
January,	33	V. slight.	.36	.0045	.0130	.0106	.22	.018	.0002	.39	1.3	.0200	12,500
February,	33	V. slight.	.35	.0058	.0153	.0132	.25	.017	.0000	.39	1.3	.0195	7,000
March,	41	V. slight.	.35	.0025	.0165	.0132	.15	.010	.0000	.39	1.1	.0255	4,100
April,	52	V. slight.	.35	.0030	.0164	.0149	.17	.008	.0001	.37	1.0	.0310	2,200
May,	66	V. slight.	.34	.0078	.0182	.0136	.23	.013	.0001	.44	1.6	.0345	4,100
June,	65	V. slight.	.55	.0079	.0234	.0206	.24	.009	.0002	.50	1.5	.0220	18,200
July,	76	V. slight.	.53	.0119	.0260	.0223	.25	.010	.0002	.61	1.7	.0390	3,800
August,	71	V. slight.	.37	.0141	.0230	.0214	.30	.014	.0004	.50	1.7	.0500	4,000
September,	70	V. slight.	.39	.0174	.0205	.0168	.37	.014	.0005	.43	1.5	.0720	38,400
October,	54	V. slight.	.45	.0136	.0198	.0156	.40	.013	.0005	.53	1.5	.0580	40,300
November,	42	V. slight.	.44	.0093	.0209	.0173	.39	.014	.0003	.65	1.4	.0593	5,300
December,	33	Slight.	.41	.0100	.0197	.0137	.33	.016	.0001	.59	1.2	.0500	14,500
Average,	53	-	.41	.0090	.0194	.0161	.28	.013	.0002	.48	1.4	.0401	12,900

Effluent of the Lawrence City Filter. — Tap at Pumping Station.

[Parts per 100,000.]

1903.	Temperature. Deg. F.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Soluble.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Bacteria per Cubic Centimeter.
Average, . . .	54	-	.42	.0096	.0062	.0075	.29	.032	.0001	.32	2.0	32

Water from the Outlet of the Lawrence Reservoir.

1903.	Temperature. Deg. F.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Soluble.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Bacteria per Cubic Centimeter.
Average, . . .	53	-	.34	.0049	.0061	.0073	.29	.042	.0002	.29	1.7	44

Water from a Tap at Lawrence City Hall.

1903.	Temperature. Deg. F.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Soluble.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Bacteria per Cubic Centimeter.
Average, . . .	53	-	.34	.0033	.0080	-	.29	.042	.0001	.27	1.7	49

Water from a Tap at the Lawrence Experiment Station.

1903.	Temperature. Deg. F.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Soluble.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Bacteria per Cubic Centimeter.
Average, . . .	53	-	.30	.0020	.0068	-	.29	.042	.0000	.26	1.8	46

Merrimack River Water as it flows upon Lawrence City Filter.

[Average of Bacterial Analyses.]

1903.	Average Number of Bacteria per c.c.	Number of Samples tested for B. Coli.	Number of Times B. Coli was found.	Average Number of B. Coli per c.c.	Per Cent. of Samples containing B. Coli.
January, ...	12,500	26	25	32	96
February, ...	7,000	23	23	23	100
March, ...	4,100	25	24	40	96
April, ...	2,200	25	25	24	100
May, ...	4,100	22	22	58	100
June, ...	18,200	15	15	141	100
July, ...	3,800	4	4	68	100
August, ...	4,000	5	5	66	100
September, ...	38,400	22	21	141	96
October, ...	40,300	24	24	178	100
November, ...	5,300	22	22	70	100
December, ...	14,500	25	25	95	100
Average, ...	12,900	-	-	78	-
Total, ...	-	238	235	-	99

Effluent of Lawrence City Filter.

[**Average of Bacterial Analyses.**

1903.	Average Number of Bacteria per c.c.	Per Cent. removed. (Efficiency.)	Number of Samples tested for B. Coli.		Number of Times B. Coli was found.		Per Cent of Samples containing B. Coli.	
			1 c.c.	100 c.c.	1 c.c.	100 c.c.	1 c.c.	100 c.c.
January, ...	58	99.5	26	26	0	0	0.0	0.0
February, ...	33	99.6	23	23	1	3	4.0	13.0
March, ...	20	99.5	25	25	2	2	8.0	8.0
April, ...	12	99.5	25	25	2	2	8.0	8.0
May, ...	18	99.6	22	22	0	4	0.0	18.2
June, ...	14	99.9	15	15	0	9	0.0	60.0
July, ...	18	99.5	4	4	1	3	25.0	75.0
August, ...	17	99.6	5	5	1	1	20.0	20.0
September, ...	20	99.9	21	21	0	2	0.0	9.5
October, ...	29	99.9	24	24	0	1	0.0	4.2
November, ...	82	99.4	23	23	2	3	8.9	13.0
December, ...	110	99.2	25	25	1	1	4.0	4.0
Average, ...	32	99.7	238	238	10	31	4.2	13.0

Water from the Outlet of the Lawrence Reservoir.

[**Average of Bacterial Analyses.**]

January, ...	70	99.4	26	26	0	0	0.0	0.0
February, ...	98	98.6	23	23	0	1	0.0	4.0
March, ...	43	99.0	25	25	2	0	8.0	0.0
April, ...	15	99.3	24	24	0	0	0.0	0.0
May, ...	24	99.4	22	22	0	1	0.0	4.5
June, ...	32	99.8	15	15	0	2	0.0	13.3
July, ...	24	99.4	4	4	0	0	0.0	0.0
August, ...	30	99.2	5	5	0	0	0.0	0.0
September, ...	31	99.9	22	22	1	0	4.5	0.0
October, ...	60	99.8	24	24	0	1	0.0	4.2
November, ...	25	99.5	23	23	1	0	4.4	0.0
December, ...	75	99.5	25	25	0	1	0.0	4.0
Average, ...	44	99.7	238	238	4	6	1.7	2.5

Water from a Tap at Lawrence City Hall.

[Average of Bacterial Analyses.]

1903.	Average Number of Bacteria per c.c.	Per Cent. removed. (Efficiency.)	Number of Samples tested for B. Coli. 1 c.c.	Number of Samples tested for B. Coli. 100 c.c.	Number of Times B. Coli was found. 1 c.c.	Number of Times B. Coli was found. 100 c.c.	Per Cent. of Samples containing B. Coli. 1 c.c.	Per Cent. of Samples containing B. Coli. 100 c.c.
January,	71	99.4	26	26	0	0	0.0	0.0
February,	75	98.9	23	23	0	2	0.0	9.0
March,	38	99.0	25	25	1	1	4.0	4.0
April,	19	99.1	25	25	2	2	8.0	8.0
May,	24	99.4	22	22	0	0	0.0	0.0
June,	45	99.7	15	15	0	2	0.0	13.3
July,	27	99.3	4	4	0	0	0.0	0.0
August,	50	98.8	5	5	0	1	0.0	20.0
September,	41	99.9	22	22	0	1	0.0	4.5
October,	85	99.7	24	24	0	1	0.0	4.2
November,	33	99.4	23	23	0	0	0.0	0.0
December,	85	99.4	25	25	1	2	4.0	8.0
	49	99.6	239	239	4	12	1.7	5.0

Lawrence City Water from a Tap at the Experiment Station.

January,	57	99.5	27	27	0	0	0.0	0.0
February,	68	99.0	23	23	0	0	0.0	0.0
March,	39	99.0	26	26	0	1	0.0	4.0
April,	13	99.4	25	25	4	4	16.0	16.0
May,	22	99.5	25	25	0	4	0.0	16.0
June,	40	99.8	24	24	0	10	0.0	42.0
July,	15	99.6	25	25	1	10	4.0	40.0
August,	38	99.1	26	26	0	7	0.0	27.0
September,	71	99.8	25	25	1	6	4.0	24.0
October,	70	99.8	27	27	2	2	7.4	7.4
November,	24	99.5	24	24	1	3	4.2	12.5
December,	95	99.3	26	26	2	5	7.7	19.2
	46	99.6	303	303	11	52	3.6	17.2

Filter No. 8 A.

Filter No. 8 A, $\frac{1}{200}$ of an acre in area, was first put into operation during 1893, and has been continued during 1903. During the year this filter contained 34 inches in depth of sand of an effective size of 0.23 millimeter. This is the oldest experimental filter in operation at the station. Its average rate during 1903 was 4,089,000 gallons per acre daily. Tables showing the results of the chemical and bacterial analysis of the canal water applied to this filter and its effluent are here given: —

Canal Water (Merrimack River Water).

[Parts per 100,000.]

1903.	Temperature.	Color.	Turbidity.	Free Ammonia.	Total Albuminoid Ammonia.	Soluble Albuminoid Ammonia.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Hardness.
January,	36	.38	V. slight.	.0059	.0130	.0116	.221	.018	.0003	.44	97.8	1.3
February,	35	.40	V. slight.	.0050	.0126	.0100	.224	.015	.0006	.39	105.7	1.3
March,	43	.34	V. slight.	.0029	.0115	.0093	.162	.010	.0000	.38	102.8	0.9
April,	52	.35	V. slight.	.0044	.0126	.0104	.160	.008	.0001	.38	100.9	1.0
May,	65	.33	V. slight.	.0096	.0187	.0146	.256	.013	.0003	.43	84.1	1.5
June,	64	.55	V. slight.	.0102	.0219	.0191	.215	.011	.0002	.58	86.1	1.3
July,	74	.54	V. slight.	.0137	.0253	.0214	.288	.014	.0003	.54	75.2	1.7
August,	69	.41	V. slight.	.0116	.0210	.0183	.297	.019	.0004	.52	72.9	1.6
September,	70	.41	V. slight.	.0161	.0179	.0137	.369	.016	.0005	.40	67.9	1.5
October,	58	.42	V. slight.	.0122	.0157	.0130	.403	.018	.0006	.57	71.2	1.5
November,	48	.43	V. slight.	.0094	.0208	.0165	.383	.017	.0003	.67	90.7	1.4
December,	36	.41	Slight.	.0116	.0233	.0170	.325	.017	.0001	.61	99.8	0.8
Average,	54	.41	–	.0094	.0178	.0146	.275	.015	.0003	.49	81.9	1.3

Effluent from Filter No. 8 A.

[Parts per 100,000.]

1903.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature, Effluent.	Color.	Turbidity.	Free Ammonia.	Total Albuminoid Ammonia.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Hardness.
January,	4,069,100	34	.33	0	.0012	.0080	.216	.026	.0001	.39	86.4	1.3
February,	4,738,600	34	.33	0	.0007	.0068	.218	.022	.0000	.32	93.0	1.4
March,	3,399,100	41	.31	0	.0006	.0055	.160	.016	.0000	.31	88.3	0.8
April,	4,813,000	51	.27	0	.0006	.0066	.156	.014	.0000	.31	75.2	0.9
May,	4,111,800	63	.20	0	.0009	.0062	.246	.031	.0000	.32	37.8	1.3
June,	3,127,200	64	.34	0	.0011	.0097	.179	.027	.0001	.42	28.0	1.3
July,	4,331,300	73	.34	0	.0026	.0108	.238	.031	.0003	.44	32.1	1.4
August,	3,793,600	65	.27	0	.0008	.0100	.314	.047	.0000	.37	54.5	1.5
September,	4,534,400	68	.26	0	.0010	.0084	.376	.034	.0004	.30	17.1	1.5
October,	4,391,500	62	.23	0	.0002	.0054	.386	.034	.0000	.28	22.8	1.7
November,	3,943,800	42	.36	0	.0024	.0099	.405	.026	.0000	.54	70.7	1.5
December,	3,819,200	34	.38	0	.0050	.0111	.330	.022	.0000	.49	79.6	0.8
Average,	4,088,900	53	.30	0	.0014	.0082	.268	.027	.0001	.37	57.1	1.3

Canal Water (Merrimack River Water applied to Experimental Filters).

[Average of Bacterial Analyses.]

1903.	Average Number of Bacteria per c.c.	Number of Samples tested for B. Coli.	Number of Times B. Coli was found.	Average Number of B. Coli per c.c.	Per Cent. of Samples containing B. Coli.
January,	6,700	25	24	26	96.0
February,	4,300	23	23	19	100.0
March,	3,100	26	25	19	96.0
April,	1,700	25	25	18	100.0
May,	4,300	25	23	41	92.0
June,	11,700	24	24	76	100.0
July,	12,000	26	26	108	100.0
August,	13,500	26	26	128	100.0
September,	20,300	25	25	116	100.0
October,	14,600	27	27	102	100.0
November,	3,000	18	18	42	100.0
December,	9,500	26	26	47	100.0
	8,700	296	292	62	98.6

Filter No. 8 A.

[Average of Bacterial Analyses.]

1903.	Average Number of Bacteria per c.c.	Per Cent. removed. (Efficiency.)	Number of Samples tested for B. Coli.		Number of Times B. Coli was found.		Per Cent of Samples containing B. Coli.	
			1 c.c.	100 c.c.	1 c.c.	100 c.c.	1 c.c.	100 c.c.
January,	125	98.1	23	23	2	3	9.0	13.0
February,	67	98.4	21	21	2	4	10.0	19.0
March,	36	99.0	9	9	2	1	22.0	11.0
April,	14	99.2	23	23	4	4	17.0	17.0
May,	16	99.6	21	21	0	3	0.0	14.3
June,	31	99.7	19	19	1	13	5.2	68.4
July,	12	99.9	24	24	1	13	4.2	54.1
August,	18	99.9	25	25	1	11	4.0	44.0
September,	13	99.9	24	24	1	16	4.2	66.6
October,	65	99.5	16	16	1	9	6.3	56.2
November,	75	97.5	17	17	1	7	5.9	41.3
December,	230	97.5	24	24	15	8	62.5	33.3
	58	99.3	246	246	31	92	12.6	37.4

Filters Nos. 218, 220 and 219.

At the beginning of July, 1903, three filters were put in operation for the purpose of studying the chemical and bacterial quality of the effluents resulting from filtering waters of three different degrees of pollution. These filters were numbered 218, 219 and 220. Filters Nos. 218 and 219 are each $\frac{1}{10000}$ of an acre in area, and Filter No. 220 is $\frac{1}{5000}$ of an acre in area. Filter No. 218 has received the least polluted water and Filter No. 219 the most polluted water, the water applied to Filter No. 220 being midway in degree of pollution between the waters applied to the other two filters. Each filter was intended to be operated at a rate of 2,500,000 gallons per acre daily, and, actually, each filter was operated as follows: Filter No. 218 at an average rate of 2,345,000 gallons per acre daily; Filter No. 220 at an average rate of 2,281,000 gallons per acre daily; and Filter No. 219 at an average rate of 2,293,000 gallons per acre daily.

The water applied to these filters varied in degree of organic pollution as follows: the free ammonia was .0028, .0126 and .0429, respectively; the albuminoid ammonia was .0119, .0221 and .0261, respectively; and the oxygen consumed was .32, .51 and .51, respectively.

The effluents of the three filters, in order of the degree of pollution of the applied waters, had free ammonia as follows: .0006, .0029 and .0037; while the albuminoid ammonias were .0068, .0125 and .0129, respectively. The per cent. of dissolved oxygen remaining in each water after filtration ranged as follows: 54.4, 37.3 and 33.4 per cent., respectively.

Turning to the bacterial results it will be noticed by the tables given beyond that the average number of bacteria applied to the three filters in the order of the degree of pollution of the waters was 1,800, 12,200 and 34,600 per cubic centimeter, respectively, while the average number of bacteria in the effluent of each filter was 34, 52 and 136, respectively, giving bacterial efficiencies of 97.1 per cent., 99.4 per cent. and 99.5 per cent.; that is, the greatest bacterial efficiency reckoned by percentages was obtained with the filter receiving the most polluted water, although the number of bacteria in its effluent was four times as great as in the effluent of the filter receiving the least polluted water.

The study was particularly interesting in showing the B. coli efficiency of each filter receiving these differing grades of water. The filter receiving the least polluted water had applied to it but 7 B. coli per cubic centimeter; the water applied to the intermediate filter contained 90 B. coli per cubic centimeter, while the most polluted water, applied to Filter No. 219, contained 339 B. coli per cubic centimeter; 7.9 per cent. of the samples of Filter No. 218 showed B. coli when testing 1 cubic centimeter; 10.8 per cent. of the samples of the effluent of Filter No. 220 when testing 1 cubic centimeter; and 15.9 per cent. of the samples of the effluent of Filter No.

219 when testing 1 cubic centimeter; that is, Filter No. 219, receiving water containing nearly fifty times as many B. coli as in the water applied to Filter No. 218, produced an effluent giving only twice as many positive tests for B. coli.

Turning to the results from examining 100 cubic centimeters of the effluent of each filter, we find that Filter No. 218, receiving the least polluted water, showed 28.3 per cent. of these samples positive when examining for B. coli; with Filter No. 220, 25.9 per cent. of the samples of the effluent gave positive results; and 37.6 per cent. of the samples of the effluent of Filter No. 219. These results indicate that the actual number of B. coli present in the effluent of the filter receiving the most polluted water was only slightly greater than the number present in the effluent of the filter receiving the least polluted water.

The tables giving average chemical and bacterial analyses follow: —

Applied Water for Filter No. 218.

[Parts per 100,000.]

1903.	Temperature. Deg. F.	Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Hardness.
		Turbidity.	Color.	Free.	Albuminoid. Total.	Albuminoid. Soluble.		Nitrates.	Nitrites.			
July,	69	None.	.29	.0036	.0152	-	.31	.036	.0000	.27	71.3	1.9
August,	66	V. slight.	.25	.0026	.0120	-	.31	.040	.0000	.31	67.7	1.9
September,	71	None.	.30	.0046	.0118	-	.36	.015	.0000	.29	67.6	1.7
October,	60	None.	.28	.0018	.0103	-	.42	.039	.0000	.28	77.6	1.8
November,	55	V. slight	.34	.0012	.0106	-	.41	.036	.0000	.39	91.1	2.2
December,	46	V. slight.	.35	.0033	.0115	-	.41	.037	.0000	.35	86.7	2.1
Average,	61	-	.30	.0028	.0119	-	.37	.034	.0000	.32	77.0	1.9

Applied Water for Filter No. 220.

July,	72	V. slight.	.50	.0182	.0278	.0264	.37	.016	.0004	.41	75.6	1.8
August,	68	V. slight.	.43	.0107	.0208	.0185	.30	.018	.0003	.51	76.3	1.6
September,	71	V. slight.	.31	.0138	.0214	.0166	.39	.019	.0005	.43	62.0	1.6
October,	58	V. slight.	.41	.0121	.0212	.0176	.41	.020	.0004	.50	61.1	1.7
November,	50	V. slight.	.42	.0076	.0180	.0160	.43	.016	.0004	.62	86.0	1.9
December,	38	V. slight.	.40	.0131	.0236	.0183	.42	.022	.0004	.61	93.8	1.7
Average,	60	-	.41	.0126	.0221	.0159	.39	.018	.0004	.51	75.8	1.7

Applied Water for Filter No. 219.

July,	71	V. slight	.55	.0772	.0346	-	.47	.013	.0003	.38	73.2	2.1
August,	69	V. slight.	.44	.0226	.0232	-	.35	.015	.0004	.52	65.3	1.7
September,	72	V. slight.	.33	.0575	.0285	-	.49	.019	.0004	.44	56.6	2.1
October,	56	V. slight.	.42	.0460	.0303	-	.52	.023	.0003	.53	60.6	1.7
November,	51	V. slight.	.44	.0332	.0240	-	.52	.023	.0004	.60	77.9	1.9
December,	42	V. slight	.39	.0207	.0158	-	.42	.022	.0005	.58	89.1	1.8
Average,	60	-	.43	.0429	.0261	-	.46	.019	.0004	.51	70.4	1.9

Effluent of Filter No. 218.

[Parts per 100,000.]

1903.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Hardness.
July, . .	2,313,900	67	V. slight.	.27	.0012	.0112	.27	.032	.0000	.22	57.6	2.6
August, .	2,202,300	66	None.	.22	.0007	.0075	.30	.037	.0002	.25	41.6	2.3
September, .	2,314,500	71	None.	.18	.0008	.0062	.36	.023	.0002	.22	38.3	2.4
October, .	2,341,600	58	None.	.22	.0003	.0056	.41	.040	.0000	.25	49.3	2.2
November, .	2,517,400	54	None.	.28	.0002	.0058	.41	.036	.0000	.37	63.9	2.1
December, .	2,380,000	47	None.	.27	.0004	.0045	.41	.044	.0000	.33	75.7	2.2
Average,	2,345,000	61	-	.24	.0006	.0068	.36	.035	.0001	.27	54.4	2.3

Effluent of Filter No. 220.

July, . .	2,335,900	60	V. slight.	.45	.0018	.0174	.38	.022	.0002	.28	25.4	3.2
August, .	2,094,200	67	V. slight.	.42	.0015	.0150	.31	.022	.0000	.45	29.9	2.9
September, .	2,320,800	71	V. slight.	.58	.0024	.0170	.43	.004	.0008	.44	24.3	3.6
October, .	2,069,600	57	None.	.33	.0004	.0096	.44	.037	.0000	.37	33.3	2.8
November, .	2,421,500	51	None.	.32	.0002	.0074	.43	.036	.0000	.46	41.9	2.0
December, .	2,445,000	42	None.	.30	.0114	.0085	.41	.026	.0003	.44	68.9	2.0
Average,	2,281,200	58	-	.40	.0029	.0125	.40	.024	.0002	.41	37.3	2.7

Effluent of Filter No. 219.

July, . .	2,091,900	69	V. slight.	.38	.0024	.0170	.48	.055	.0002	.27	32.4	5.3
August, .	2,054,000	60	V. slight	.60	.0017	.0173	.35	.019	.0008	.48	18.5	2.9
September, .	2,373,500	70	V. slight.	.55	.0018	.0154	.42	.001	.0030	.43	23.4	2.6
October, .	2,252,500	56	None.	.43	.0007	.0121	.51	.039	.0000	.43	32.7	2.2
November, .	2,545,000	51	None.	.32	.0002	.0078	.46	.038	.0000	.48	39.8	1.9
December, .	2,440,000	45	None.	.29	.0157	.0081	.42	.039	.0014	.43	53.7	1.8
Average,	2,292,800	60	-	.43	.0037	.0129	.44	.032	.0009	.42	33.4	2.8

Applied Water. — Filter No. 218.

[Average of Bacterial Analyses.]

1903.	Average Number of Bacteria per c.c.	Number of Samples tested for B. Coli.	Number of Times B. Coli was found.	Average Number of B. Coli per c c.	Per Cent. of Samples containing B. Coli.
July,	1,700	10	10	8	100.0
August,	2,100	26	23	.10	88.5
September,	3,500	18	18.	11	100.0
October,	1,900	25	17	3	68.0
November,	250	19	16	4	84.2
December,	1,500	25	23	7	92.0
	1,800	123	107	7	57.0

Applied Water. — Filter No. 220.

July,	12,000	26	26	108	100.0
August,	13,500	26	26	128	100.0
September,	20,300	25	25	116	100.0
October,	14,600	27	27	102	100.0
November,	3,000	18	18	42	100.0
December,	9,500	26	26	47	100.0
	12,200	148	148	90	100.0

Applied Water. — Filter No. 219.

July,	58,500	9	9	458	100.0
August,	19,600	25	25	349	100.0
September,	38,700	18	18	455	100.0
October,	43,800	24	24	348	100.0
November,	17,100	17	17	253	100.0
December,	29,700	25	25	130	100.0
	34,600	118	118	339	100.0

Effluent.— Filter No. 218.

[Average of Bacterial Analyses.]

1903.	Average Number of Bacteria per c.c.	Per Cent. removed. (Efficiency.)	Number of Samples tested for B. Coli. 1 c.c.	Number of Samples tested for B. Coli. 100 c.c.	Number of Times B. Coli was found. 1 c.c.	Number of Times B. Coli was found. 100 c.c.	Per Cent of Samples containing B. Coli. 1 c.c.	Per Cent of Samples containing B. Coli. 100 c.c.
August,	37	98.2	26	26	2	14	7.7	54.0
September,	47	98.7	18	18	0	9	0.0	50.0
October,	17	99.1	25	25	0	5	0.0	20.0
November,	18	92.8	19	19	0	1	0.0	5.3
December,	52	96.5	25	25	8	3	32.0	12.0
	34	97.1	113	113	10	32	7.9	28.3

Effluent.— Filter No. 220.

1903.	Average Number of Bacteria per c.c.	Per Cent. removed. (Efficiency.)	Number of Samples tested for B. Coli. 1 c.c.	Number of Samples tested for B. Coli. 100 c.c.	Number of Times B. Coli was found. 1 c.c.	Number of Times B. Coli was found. 100 c.c.	Per Cent of Samples containing B. Coli. 1 c.c.	Per Cent of Samples containing B. Coli. 100 c.c.
August,	56	99.6	25	25	1	18	4.0	76.0
September,	54	99.7	18	18	0	0	0.0	0.0
October,	44	99.7	24	24	0	5	0.0	20.8
November,	35	98.8	18	18	4	3	22.2	16.7
December,	70	99.3	25	25	7	4	28.0	16.0
	52	99.4	110	110	12	30	10.8	25.9

Effluent.— Filter No. 219.

1903.	Average Number of Bacteria per c.c.	Per Cent. removed. (Efficiency.)	Number of Samples tested for B. Coli. 1 c.c.	Number of Samples tested for B. Coli. 100 c.c.	Number of Times B. Coli was found. 1 c.c.	Number of Times B. Coli was found. 100 c.c.	Per Cent of Samples containing B. Coli. 1 c.c.	Per Cent of Samples containing B. Coli. 100 c.c.
August,	170	99.1	25	25	2	10	8.0	40.0
September,	98	99.7	18	18	1	8	5.6	44.5
October,	190	99.6	24	24	3	14	12.5	58.3
November,	80	99.5	17	17	5	5	29.4	29.4
December,	140	99.5	25	25	6	4	24.0	16.0
	136	99.5	109	109	17	41	15.9	37.6

Filter No. 216.

Early in 1903 experiments began to be made in regard to filtering Merrimack River water at a high rate with the aid of a sulphate of alumina as a coagulant. A so-called mechanical filter for this purpose was constructed at Lawrence, this filter being a wooden tank 28 inches in diameter, or approximately $\frac{1}{10000}$ of an acre in area, and containing sand which at first had an effective size of 0.38 millimeter. Many washings of this sand, however, caused the removal of the finer particles and increased its effective size. About one inch above the bottom of the wooden tank was placed a perforated galvanized iron strainer held upon supports. Above this was

arranged 6 inches in depth of gravel underdrains and above these underdrains 2.5 feet in depth of sand. The water before coming to the filter passed through a settling tank of such capacity that when the filter was operating at a rate of 50,000,000 gallons per acre daily about one hour's sedimentation was obtained. The coagulant was added as the water entered the settling basin.

This filter was operated from May 27 until the middle of October, and during this period many series of runs were made, operating the filter (1) with a varying amount of coagulant and at a constant rate; and (2) with a constant amount of coagulant and at a varying rate. Throughout the entire experiment during 1903 numerous determinations of the number of bacteria present in the raw water, the water after passing the sedimentation tank and the effluent of the filter were made. Each run shown on subsequent tables represents a period between washings; that is, at the rapid rate of filtration followed with this filter and with the use of a coagulant the dirt and chemicals accumulated upon the sand in the filter needed frequent removal. This was accomplished by reversing the current of water through the filter, stirring the surface of the sand by means of water jets, and allowing the wash-water to flow away from orifices in the side of the filter some distance above the surface of the sand.

Besides the bacterial examinations, many chemical analyses were also made, especial attention being given to determining the coloring and organic matter removed, and also the alkalinity of the applied water and the effluent of the filter, this last determination being necessary to determine if more than enough coagulant was used to become decomposed by the carbonates present in the water and thus render the effluent acid on account of the presence of undecomposed sulphate.

Studying the results obtained with this filter we find that, leaving all considerations aside in regard to the desirability of purifying water by means of the addition of a chemical, no evidence was given that continued results, equal in bacterial efficiency to the results of slow sand filtration, could be obtained in this way with such water as flows in the Merrimack River; that is, unless adding an amount of coagulant too great to be successfully or uniformly well handled by the carbonates in the raw water.

During many of the runs the efficiency of the filter was very great, but even during some of the best runs periods would occur when the efficiency was low, and from time to time the efficiency would be low during the entire run, although the filter was apparently being handled as well as usual.

The investigation was especially interesting, as at most locations, such as Louisville, Pittsburg, Cincinnati, etc., where prolonged, elaborate and skillful investigations upon this method of water purification have been carried out, the water studied, while turbid and more or less polluted, has not approached in sewage and factory pollution the condition of the water in the Merrimack River at Lawrence used in this investigation. Moreover,

the alkalinity of the Merrimack River water is much less than that of the western river waters studied in the investigations mentioned, and hence the amount of sulphate of alumina that can be depended upon to become decomposed is very much smaller than the amount that can be used and decomposed when handling the western river waters; in fact, it was only when using an amount so great that from time to time the effluent was acid that entire removal of color could be obtained, and it was at such periods that the greatest bacterial efficiency was, of course, given.

Studying the series of results presented in subsequent tables, it will be noticed that experiments with rates of filtration varying at the beginning of each run from 100,000,000 to 30,000,000 gallons per acre daily were made as follows: —

From May 26 to May 27, inclusive, 2 runs, at a rate of 100,000,000 gallons per acre daily, with the use of ½ grain of coagulant per gallon.

From May 28 to June 6, inclusive, 9 runs, at a rate of 50,000,000 gallons per acre daily, with the use of ½ grain of coagulant per gallon.

From June 7 to June 13, 6 runs, at a rate of 40,000,000 gallons per acre daily, with the use of ½ grain of coagulant per gallon.

From June 14 to June 20, 6 runs, at a rate of 30,000,000 gallons per acre daily, with the use of ½ grain of coagulant per gallon.

From June 21 to July 11, 14 runs, at a rate of 30,000,000 gallons per acre daily, with the use of ¾ grain of coagulant per gallon.

From July 12 to July 18, 6 runs, at a rate of 30,000,000 gallons per acre daily, with the use of 1 grain of coagulant per gallon.

From July 19 to August 24, 46 runs, at a rate of 30,000,000 gallons per acre daily, with the use of 1¼ grains of coagulant per gallon.

From August 25 to August 29, inclusive, 9 runs, at a rate of 50,000,000 gallons per acre daily, with the use of ⅝ grain of coagulant per gallon.

From August 31 to September 1, inclusive, 4 runs, at a rate of 50,000,000 gallons per acre daily, with the use of ⅞ grain of coagulant per gallon.

From September 2 to September 3, inclusive, 4 runs, at a rate of 50,000,000 gallons per acre daily, with the use of 1 grain of coagulant per gallon.

From September 4 to September 7, inclusive, 3 runs, at a rate of 50,000,000 gallons per acre daily, with the use of 1⅛ grains of coagulant per gallon.

From September 8 to September 9, inclusive, 4 runs, at a rate of 50,000,000 gallons per acre daily, with the use of 1¼ grains of coagulant per gallon.

From September 10 to September 12, 5 runs, at a rate of 50,000,000 gallons per acre daily, with the use of 1⅜ grains of coagulant per gallon.

From September 13 to September 16, inclusive, 6 runs, at a rate of 50,000,000 gallons per acre daily, with the use of 1½ grains of coagulant per gallon.

From September 17 to September 19, inclusive, 5 runs, at a rate of 50,000,000 gallons per acre daily, with the use of 1⅝ grains of coagulant per gallon.

From September 21 to September 23, inclusive, 6 runs, at a rate of 50,000,000 gallons per acre daily, with the use of 1¾ grains of coagulant per gallon.

From September 24 to September 26, inclusive, 5 runs, at a rate of 50,000,000 gallons per acre daily, with the use of 1⅞ grains of coagulant per gallon.

From September 28 to September 30, inclusive, 6 runs, at a rate of 50,000,000 gallons per acre daily, with the use of 2 grains of coagulant per gallon.

From October 1 to October 6, inclusive, 6 runs, at a rate of 50,000,000 gallons per acre daily, with the use of 1⅝ grains of coagulant.

From October 7 to October 10, inclusive, 7 runs, at a rate of 50,000,000 gallons per acre daily, with the use of 1 grain of coagulant per gallon.

From October 12 to October 14, inclusive, 6 runs, at a rate of 50,000,000 gallons per acre daily, with the use of ⅞ grain of coagulant per gallon.

From October 15 to October 16, inclusive, 3 runs, at a rate of 50,000,000 gallons per acre daily, with the use of ¾ grain of coagulant per gallon.

In order to show the results obtained during this series of runs tables have, in the first place, been made showing the average results for each run; and in the second place, tables showing the results from hour to hour during representative runs. Studying the general average of the runs the following points may be noticed: —

Rates.

It was practically impossible with the grade of sand used in the filter and with Merrimack River water to maintain rates as great as 100,000,000 gallons per acre daily except for a very short period at the beginning of each run. Even when starting at a rate only one-half as great, namely, 50,000,000 gallons per acre daily, the rate was rapidly reduced.

Bacterial Efficiency.

When first operating the filter from May 26 to May 27, inclusive, at the rate at the start of 100,000,000 gallons per acre daily, the efficiency of the system varied; the percentage of bacteria removed by coagulation, sedimentation and filtration averaged 95.6, and the average number of bacteria in the effluent of the filter was 285 per cubic centimeter.

When reducing the rate to one-half that first used, namely, to 50,000,000 gallons per acre daily, the average efficiency of the system from May 28 to June 6, inclusive, was even less, varying from an average of 95.2 per cent. during each morning to 81.9 per cent. during each afternoon.

From June 7 to June 13, inclusive, during a period of 6 runs, at a rate of 40,000,000 gallons per acre daily, the average efficiency of the system was 99 per cent.

30,000,000 Rate.

From June 14 to June 20, during a period of 6 runs, at a rate of 30,000,000 gallons per acre daily, the average efficiency of the system was 92.7 per cent. During these runs ½ grain of coagulant per gallon was used.

From June 21 to July 11, during a period of 14 runs, at a rate of 30,000,000 gallons per acre daily, the average efficiency of the system was 96.3 per cent., the amount of coagulant used being ¾ grain per gallon.

From July 12 to July 18, when operating at the same rate, namely, 30,000,000 gallons per acre daily, but with the use of 1 grain of coagulant per gallon, the average efficiency of the system was 98.1 per cent.

From July 19 to August 3, operating at the same rate but with the use of 1¼ grains of coagulant per gallon, the average efficiency of the system was 98.7 per cent. during a period of 13 runs.

From August 4 to August 24, during a period of 33 runs, at an average rate of 30,000,000 gallons per acre daily, with the use of 1¼ grains of coagulant per gallon, the average efficiency of the system was 97 per cent.

50,000,000 Rate.

From August 25 to August 29, during a period of 9 runs, at a rate of 50,000,000 gallons per acre daily and with the use of ¾ grain of coagulant per gallon, the average efficiency of the system was 97.2 per cent.

From August 31 to September 1, operating at the same rate but with the use of ⅞ grain of coagulant per gallon, the average efficiency of the system was 99.9 per cent.

From September 2 to September 3, inclusive, operating at the same rate but with the use of 1 grain per gallon, the average efficiency of the system was the same, namely, 99.9 per cent.

From September 4 to September 7, operating at the same rate but with the use of 1⅛ grains of coagulant per gallon, the average efficiency of the system was 99.5 per cent.

From September 8 to September 9, operating at the same rate but with the use of 1¼ grains of coagulant per gallon, the average efficiency of the system was 99.9 per cent.

From September 10 to September 12, operating at the same rate but with the use of 1⅜ grains of coagulant per gallon, the average efficiency of the system was 99.9 per cent.

From September 13 to September 16, operating at the same rate but with the use of 1½ grains of coagulant per gallon, the average efficiency of the system was 98.3 per cent.

From September 17 to September 19, operating at the same rate but with the use of 1⅝ grains of coagulant per gallon, the average efficiency of the system was 95.6 per cent.

From September 21 to September 23, operating at the same rate but with the use of 1¾ grains of coagulant per gallon, the average efficiency of the system was 99.9 per cent.

From September 24 to September 26, operating at the same rate but with the use of 1⅞ grains of coagulant per gallon, the average efficiency of the system was 99.9 per cent.

From September 28 to September 30, operating at the same rate but with the use of 2 grains of coagulant per gallon, the average efficiency of the system was 99.9 per cent.

From October 1 to October 6, operating at the same rate but with the use of 1⅝ grains of coagulant per gallon, the average efficiency of the system was 99.9 per cent.

From October 7 to October 10, operating at the same rate but with the use of 1 grain of coagulant per gallon, the average efficiency of the system was 99.5 per cent.

From October 12 to October 14, operating at the same rate but with the use of ⅞ grain of coagulant per gallon, the average efficiency of the system was 99.9 per cent.

From October 15 to October 16, operating at the same rate but with the use of ¾ grain of coagulant per gallon, the average efficiency of the system was 98.4 per cent

Tables showing these results follow, the bacteria being given as usual, that is, the number per cubic centimeter: —

Filter No. 216.

Period,	May 26–May 27	May 28–June 6
Number of runs,	2	9
Average number of hours per run,	12 hrs. 30 mins.	21 hrs. 10 mins.
Intended rate (gallons per acre daily),	100,000,000	50,000,000
Actual rate, beginning of run (gallons per acre daily),	100,000,000	51,502,000
Actual rate, end of run (gallons per acre daily),	20,520,000	24,695,600
Gallons per acre per twenty-four hours,	44,736,000	40,376,600
Coagulant (grains per gallon)	½	½
Average number of bacteria in river water,	7,400	17,450
Average number of bacteria in effluent,	285	1,750
Per cent. of bacteria removed,	95.6	88.5

Period,	June 7–June 13	June 14–June 20
Number of runs,	6	6
Average number of hours per run,	20 hrs. 35 mins.	18 hrs. 5 mins.
Intended rate (gallons per acre daily),	40,000,000	30,000,000
Actual rate, beginning of run (gallons per acre daily),	40,106,700	30,000,000
Actual rate, end of run (gallons per acre daily),	19,200,000	29,200,000
Gallons per acre per twenty-four hours,	25,931,600	29,145,000
Coagulant (grains per gallon)	½	½
Average number of bacteria in river water,	24,600	4,700
Average number of bacteria in effluent,	225	338
Per cent. of bacteria removed,	99	92.7

Period,	June 21–July 11	July 12–July 18
Number of runs,	14	6
Average number of hours per run,	22 hrs. 5 mins.	20 hrs. 45 mins.
Intended rate (gallons per acre daily),	30,000,000	30,000,000
Actual rate, beginning of run (gallons per acre daily),	30,000,000	30,280,000
Actual rate, end of run (gallons per acre daily),	21,497,100	18,680,000
Gallons per acre per twenty-four hours,	26,017,800	25,630,800
Coagulant (grains per gallon)	¾	1
Average number of bacteria in river water,	11,550	12,350
Average number of bacteria in effluent,	450	215
Per cent. of bacteria removed,	96.3	98.1

Period,	July 19–Aug. 3	Aug. 4–Aug. 24
Number of runs,	13	33
Average number of hours per run,	21 hrs. 4 mins.	11 hrs. 17 mins.
Intended rate (gallons per acre daily),	30,000,000	30,000,000
Actual rate, beginning of run (gallons per acre daily),	30,129,200	30,000,000
Actual rate, end of run (gallons per acre daily),	16,283,100	25,629,100
Gallons per acre per twenty-four hours,	24,106,300	25,920,000
Coagulant (grains per gallon	1¼	1¼
Average number of bacteria in river water,	10,650	11,950
Average number of bacteria in effluent,	130	350
Per cent. of bacteria removed,	98.7	97

Period,	Aug. 25–Aug. 29	Aug. 31–Sept. 1
Number of runs,	9	4
Average number of hours per run,	11 hrs. 9 mins.	11 hrs. 45 mins.
Intended rate (gallons per acre daily),	50,000,000	50,000,000
Actual rate, beginning of run (gallons per acre daily),	50,560,000	50,400,000
Actual rate, end of run (gallons per acre daily),	38,720,000	18,360,000
Gallons per acre per twenty-four hours,	40,890,000	33,550,000

Filter No. 216 — Continued.

Coagulant (grains per gallon),	3/4	7/8
Average number of bacteria in river water,	19,500	18,900
Average number of bacteria in effluent,	550	5
Per cent. of bacteria removed,	97.2	99.9
Period,	Sept. 2–Sept. 3	Sept. 4–Sept. 7
Number of runs,	4	3
Average number of hours per run,	11 hrs. 27 mins.	9 hrs. 57 mins.
Intended rate (gallons per acre daily),	50,000,000	50,000,000
Actual rate, beginning of run (gallons per acre daily),	50,000,000	50,000,000
Actual rate, end of run (gallons per acre daily),	28,440,000	37,920,000
Gallons per acre per twenty-four hours,	37,440,000	41,760,000
Coagulant (grains per gallon),	1	1 1/8
Average number of bacteria in river water,	13,100	11,500
Average number of bacteria in effluent,	5	53
Per cent. of bacteria removed,	99.9	99.5
Period,	Sept. 8–Sept. 9	Sept. 10–Sept. 12
Number of runs,	4	5
Average number of hours per run,	11 hrs. 40 mins.	10 hrs. 47 mins.
Intended rate (gallons per acre daily),	50,000,000	50,000,000
Actual rate, beginning of run (gallons per acre daily),	50,000,000	50,000,000
Actual rate, end of run (gallons per acre daily),	18,000,000	35,712,000
Gallons per acre per twenty-four hours,	33,120,000	41,760,000
Coagulant (grains per gallon),	1 1/4	1 3/8
Average number of bacteria in river water,	14,400	51,200
Average number of bacteria in effluent,	6	5
Per cent. of bacteria removed,	99.9	99.9
Period,	Sept. 13–Sept. 16	Sept. 17–Sept. 19
Number of runs,	6	5
Average number of hours per run,	11 hrs. 35 mins.	10 hrs. 46 mins.
Intended rate (gallons per acre daily),	50,000,000	50,000,000
Actual rate, beginning of run (gallons per acre daily),	50,000,000	50,000,000
Actual rate, end of run (gallons per acre daily),	24,960,000	45,504,000
Gallons per acre per twenty-four hours,	36,000,000	47,520,000
Coagulant (grains per gallon),	1 1/2	1 5/8
Average number of bacteria in river water,	5,100	3,500
Average number of bacteria in effluent,	85	155
Per cent. of bacteria removed,	98.3	95.6
Period,	Sept. 21–Sept. 23	Sept. 24–Sept. 26
Number of runs,	6	5
Average number of hours per run,	11 hrs. 33 mins.	10 hrs. 41 mins.
Intended rate (gallons per acre daily),	50,000,000	50,000,000
Actual rate, beginning of run (gallons per acre daily),	50,000,000	50,000,000
Actual rate, end of run (gallons per acre daily),	29,520,000	23,616,000
Gallons per acre per twenty-four hours,	40,320,000	36,000,000
Coagulant (grains per gallon),	1 3/4	1 7/8
Average number of bacteria in river water,	12,800	22,500
Average number of bacteria in effluent,	3	1
Per cent. of bacteria removed,	99.9	99.9
Period,	Sept. 28–Sept. 30	Oct. 1–Oct. 6
Number of runs,	6	6
Average number of hours per run,	11 hrs. 25 mins.	11 hrs. 31 mins.
Intended rate (gallons per acre daily),	50,000,000	50,000,000

Filter No. 216 — Concluded.

Actual rate, beginning of run (gallons per acre daily),	50,000,000	50,000,000
Actual rate, end of run (gallons per acre daily), .	24,960,000	21,120,000
Gallons per acre per twenty-four hours, . . .	36,000,000	34,560,000
Coagulant (grains per gallon), ...	2	1⅝
Average number of bacteria in river water, . .	16,800	25,700
Average number of bacteria in effluent, . . .	2	3
Per cent. of bacteria removed, ...	99.9	99.9

Period, ...	Oct. 7-Oct. 10	Oct. 12-Oct. 14
Number of runs, ...	7	6
Average number of hours per run, ...	10 hrs. 55 mins.	11 hrs. 32 mins.
Intended rate (gallons per acre daily), . . .	50,000,000	50,000,000
Actual rate, beginning of run (gallons per acre daily),	50,000,000	50,000,000
Actual rate, end of run (gallons per acre daily), .	34,765,700	26,400,000
Gallons per acre per twenty-four hours, . . .	41,040,000	36,860,000
Coagulant (grains per gallon), ...	1	⅞
Average number of bacteria in river water, . .	44,800	24,000
Average number of bacteria in effluent, . . .	202	12
Per cent. of bacteria removed, ...	99.5	99.9

Period, ...	Oct. 15-Oct. 16
Number of runs, ...	3
Average number of hours per run, ...	10 hrs. 30 mins.
Intended rate (gallons per acre daily), ...	50,000,000
Actual rate, beginning of run (gallons per acre daily), ...	50,000,000
Actual rate, end of run (gallons per acre daily), ...	41,613,300
Gallons per acre per twenty-four hours, ...	46,080,000
Coagulant (grains per gallon), ...	¾
Average number of bacteria in river water, ...	4,100
Average number of bacteria in effluent, ...	65
Per cent. of bacteria removed, ...	98.4

Percentage of Bacteria removed by Coagulation and Sedimentation.

From	Rate (Gallons per Acre Daily).	Coagulant (Grains per Gallon).	Percentage of Bacteria removed by Coagulation and Sedimentation.
May 26-May 27,	44,736,000	½	35.0
May 28-June 6,	40,376,600	½	–
June 7-June 13,	25,931,600	½	75.4
June 14-June 20,	29,145,000	½	42.3
June 21-July 11,	26,017,800	¾	73.8
July 12-July 18,	25,630,800	1	79.3
July 19-Aug. 3,	24,106,300	1¼	82.1
Aug. 4-Aug. 24,	25,920,000	1¼	74.3
Aug. 25-Aug. 29,	40,890,000	¾	69.2
Aug. 31-Sept. 1,	33,550,000	⅞	87.6
Sept. 2-Sept. 3,	37,440,000	1	95.6
Sept. 4-Sept. 7,	41,760,000	1⅛	–
Sept. 8-Sept. 9,	33,120,000	1¼	87.5
Sept 10-Sept. 12,	41,760,000	1⅜	93.5
Sept. 13-Sept. 16,	36,000,000	1½	89.2
Sept. 17-Sept. 19,	47,520,000	1⅝	82.9
Sept. 21-Sept. 23,	40,320,000	1¾	91.4
Sept. 24-Sept. 26,	36,000,000	1⅞	95.7
Sept. 28-Sept. 30,	36,000,000	2	98.0
Oct. 1-Oct. 6,	34,560,000	1⅝	80.5
Oct. 7-Oct. 10,	41,040,000	1	83.5
Oct. 12-Oct. 14,	36,860,000	⅞	87.9
Oct. 15-Oct. 16,	46,080,000	¾	44.0

B. Coli Results.

In all this work determinations of the number of B. coli in the raw river water, in the water after the addition of the coagulant and passage through the sedimentation tank, — that is, as applied to the filter, — and of the presence of the germ in the effluent of the filter were made. The results are given in the following table: —

Filter No. 216.

From	Average Rate of Filtration (Gallons per Acre Daily).	Coagulant (Grains per Gallon).	Average Number of B. Coli in —		Per Cent. of Samples of Effluent containing B. Coli in —	
			River Water.	Applied Water.*	1 c.c.	100 c.c.
May 26-May 27, . . .	44,736,000	½	69	13	50.0	75.0
May 28-June 6, . . .	40,376,600	½	81	31	51.7	91.7
June 7-June 13, . . .	25,931,600	½	167	35	10.0	60.0
June 14-June 20, . . .	29,145,000	½	31	34	33.3	75.0
June 21-July 11, . . .	26,017,800	¾	93	14	31.9	36.4
July 12-July 18, . . .	25,630,800	1	149	82	20.0	40.0
July 19-Aug. 3, . . .	24,106,300	1¼	124	17	13.7	40.9
Aug. 4-Aug. 24, . . .	25,920,000	1¼	130	36	23.4	30.0
Aug. 25-Aug. 29, . . .	40,890,000	¾	85	55	44.5	44.5
Aug. 31-Sept. 1, . . .	33,550,000	⅞	63	28	0.0	25.0
Sept. 2-Sept. 3, . . .	37,440,000	1	262	130	0.0	0.0
Sept. 4-Sept. 7, . . .	41,760,000	1⅛	33	3	0.0	0.0
Sept. 8-Sept. 9, . . .	33,120,000	1¼	90	4	0.0	0.0
Sept. 10-Sept. 12, . . .	41,760,000	1⅜	348	3	0.0	25.0
Sept. 13-Sept. 16, . . .	36,000,000	1½	101	15	16.7	16.7
Sept. 17-Sept. 19, . . .	47,520,000	1⅝	41	12	50.0	25.0
Sept. 21-Sept. 23, . . .	40,320,000	1¾	214	4	0.0	0.0
Sept. 24-Sept. 26, . . .	36,000,000	1⅞	81	4	0.0	50.0
Sept. 28-Sept. 30, . . .	36,000,000	2	28	1	0.0	0.0
Oct. 1-Oct. 6, . . .	34,560,000	1⅝	56	0	0.0	0.0
Oct. 7-Oct. 10, . . .	41,040,000	1	136	0	16.7	0.0
Oct. 12-Oct. 14, . . .	36,860,000	⅞	71	2	0.0	0.0
Oct. 15-Oct. 16, . . .	46,080,000	¾	19	2	33.3	0.0

* After passing through sedimentation basin.

Tables showing Bacterial Results of Representative Runs.

The following tables show the results of determinations of the number of bacteria and the presence of B. coli in samples of effluent taken at frequent intervals during representative runs from May until October, inclusive: —

Series on Filter No. 216.

	May 27, 1903. Intended Rate, 100,000,000 Gallons per Acre Daily. Coagulant per Gallon, ½ Grain.			June 5, 1903. Intended Rate, 50,000,000 Gallons per Acre Daily. Coagulant per Gallon, ½ Grain.			June 8, 1903. Intended Rate, 40,000,000 Gallons per Acre Daily. Coagulant per Gallon, ½ Grain.			June 15, 1903. Intended Rate, 30,000,000 Gallons per Acre Daily. Coagulant per Gallon, ½ Grain.		
	Bacteria per Cubic Centimeter.	B. coli.		Bacteria per Cubic Centimeter.	B. coli.		Bacteria per Cubic Centimeter.	B. coli.		Bacteria per Cubic Centimeter.	B. coli.	
		1 c.c.	100 c.c.		1 c.c.	100 c.c.		1 c.c.	100 c.c.		1 c.c.	100 c.c.
At start,	-	-	-	350	0	+	-	-	-	1,300	0	+
After 15 minutes,	653	+	+	2,100	0	+	-	-	-	-	-	-
After 30 minutes,	-	-	-	1,900	+	+	1,900	+	+	3,400	+	+
After 45 minutes,	-	-	-	2,100	+	+	-	-	-	-	-	-
After 1 hour,	817	+	+	2,000	+	0	-	-	-	-	-	-
After 1½ hours,	632	+	+	1,000	0	0	1,900	0	+	4,300	+	+
After 2 hours,	-	-	-	950	0	0	-	-	-	-	-	-
After 2¼ hours,	-	-	-	-	-	-	-	-	-	-	-	-
After 2½ hours,	795	+	+	1,300	0	+	1,300	+	+	1,200	+	+
After 3 hours,	-	-	-	2,200	+	+	-	-	-	-	-	-
After 3½ hours,	1,044	+	+	2,500	+	+	1,000	+	+	1,600	+	+
After 4 hours,	-	-	-	2,300	+	+	-	-	-	-	-	-
After 4¼ hours,	-	-	-	-	-	-	-	-	-	-	-	-
After 4½ hours,	746	0	0	-	-	-	1,200	+	0	1,500	+	+
After 5 hours,	-	-	-	2,800	0	0	-	-	-	-	-	-
After 5½ hours,	-	-	-	-	-	-	1,100	0	+	650	+	+
After 6 hours,	173	+	+	3,000	+	+	-	+	-	-	-	-
After 6¼ hours,	-	-	-	-	-	-	-	-	-	-	-	-
After 6½ hours,	-	-	-	-	-	-	2,300	+	+	1,400	0	+
After 7 hours,	-	-	-	3,900	0	0	-	-	-	-	-	-
Average,	694	-	-	2,014	-	-	1,524	-	-	1,919	-	-
Per cent. of samples tested which contained B. coli,	-	85.7	85.7	-	50.0	64.3	-	75.0	85.7	-	75.0	100.0

Series on Filter No. 216 — Continued.

	June 16, 1903. Intended Rate, 30,000,000 Gallons per Acre Daily. Coagulant per Gallon, ½ Grain.			July 8, 1903. Intended Rate, 30,000,000 Gallons per Acre Daily. Coagulant per Gallon, ¾ Grain.			July 15, 1903. Intended Rate, 30,000,000 Gallons per Acre Daily. Coagulant per Gallon, 1 Grain.			July 22, 1903. Intended Rate, 30,000,000 Gallons per Acre Daily. Coagulant per Gallon, 1¼ Grains.		
	Bacteria per Cubic Centimeter.	B. coli.		Bacteria per Cubic Centimeter.	B. coli.		Bacteria per Cubic Centimeter.	B. coli.		Bacteria per Cubic Centimeter.	B. coli.	
		1 c.c.	100 c.c.		1 c.c.	100 c.c.		1 c.c.	100 c.c.		1 c.c.	100 c.c.
At start,	-	-	-	47	0	+	40	0	+	65	0	0
After 15 minutes,	250	+	+	72	+	+	475	+	+	95	0	+
After 30 minutes,	-	-	-	76	0	+	275	0	0	110	0	+
After 45 minutes,	-	-	-	396	0	+	350	0	+	110	0	+
After 1 hour,	-	-	-	435	0	0	400	0	+	425	+	0
After 1½ hours,	-	-	-	370	+	0	500	+	0	325	0	+
After 2 hours,	-	-	-	362	+	+	425	0	+	150	0	0
After 2¼ hours,	120	+	+	-	-	-	-	-	-	-	-	-
After 2½ hours,	-	-	-	-	-	-	-	-	-	-	-	-
After 3 hours,	-	-	-	222	+	+	50	+	+	16	0	0
After 3½ hours,	-	-	-	-	-	-	-	-	-	-	-	-
After 4 hours,	-	-	-	184	+	+	15	0	+	12	0	0
After 4¼ hours,	700	+	+	-	-	-	-	-	-	-	-	-
After 4½ hours,	-	-	-	-	-	-	-	-	-	-	-	-
After 5 hours,	-	-	-	51	+	+	10	0	0	9	0	+
After 5¼ hours,	-	-	-	-	-	-	10	0	0	-	-	-
After 5½ hours,	-	-	-	-	-	-	-	-	-	-	-	-
After 6 hours,	-	-	-	24	0	0	21	0	0	16	0	0
After 6¼ hours,	475	0	+	-	-	-	-	-	-	-	-	-
After 6½ hours,	-	-	-	-	-	-	-	-	-	-	-	-
After 7 hours,	-	-	-	53	0	0	900	0	+	35	0	+
Average,	386	-	-	191	-	-	267	-	-	114	-	-
Per cent. of samples tested which contained B. coli,	-	75.0	100.0	-	50.0	66.6	-	23.1	61.5	-	8.3	50.0

Series on Filter No. 216 — Continued.

	Aug. 11, 1903. Intended Rate, 30,000,000 Gallons per Acre Daily. Coagulant per Gallon, 1¼ Grains.			Aug. 27, 1903. Intended Rate, 50,000,000 Gallons per Acre Daily. Coagulant per Gallon, ¾ Grain.			Aug. 31, 1903. Intended Rate, 50,000,000 Gallons per Acre Daily. Coagulant per Gallon, ⅞ Grain.		
	Bacteria per Cubic Centimeter.	B. coli.		Bacteria per Cubic Centimeter.	B. coli.		Bacteria per Cubic Centimeter.	B. coli.	
		1 c.c.	100 c.c.		1 c.c.	100 c.c.		1 c.c.	100 c.c.
At start,	200	+	0	56	0	0	15	0	0
After 15 minutes,	180	0	+	228	0	+	1,406	+	+
After 30 minutes,	250	0	+	630	+	+	1,172	0	0
After 45 minutes,	350	0	+	225	+	0	852	+	0
After 1 hour,	300	+	+	4,027	+	0	880	+	+
After 1½ hours,	260	0	0	390	+	0	297	+	+
After 2 hours,	150	0	+	2,556	+	0	50	0	+
After 3 hours,	34	0	0	1,342	0	+	14	0	0
After 4 hours,	3	0	+	852	+	+	13	0	0
After 5 hours,	5	0	+	420	0	0	3	0	+
After 6 hours,	2	0	+	1,172	+	0	8	0	0
After 7 hours,	-	-	-	-	-	-	3	0	0
After 8 hours,	-	-	-	-	-	-	6	0	0
After 24 hours,	35	0	+	16	0	0	7	0	0
Average,	147	-	-	993	-	-	338	-	-
Per cent. of samples tested which contained B. coli,	-	16.6	75.0	-	58.3	33.3	-	28.6	35.7

Series on Filter No. 216 — Continued.

	Sept. 2, 1903. Intended Rate, 50,000,000 Gallons per Acre Daily. Coagulant per Gallon, 1 Grain.			Sept. 4, 1903. Intended Rate, 50,000,000 Gallons per Acre Daily. Coagulant per Gallon, 1⅛ Grains.			Sept. 8, 1903. Intended Rate, 50,000,000 Gallons per Acre Daily. Coagulant per Gallon, 1¼ Grains.			Sept. 11, 1903. Intended Rate, 50,000,000 Gallons per Acre Daily. Coagulant per Gallon, 1⅜ Grains.		
	Bacteria per Cubic Centimeter.	B. coli.		Bacteria per Cubic Centimeter.	B. coli.		Bacteria per Cubic Centimeter.	B. coli.		Bacteria per Cubic Centimeter.	B. coli.	
		1 c.c.	100 c.c.		1 c.c.	100 c.c.		1 c.c.	100 c.c.		1 c.c.	100 c.c.
At start,	8	0	0	25	0	0	150	0	0	22	0	0
After 15 minutes,	16	0	+	30	0	0	1,300	0	0	4	0	0
After 30 minutes,	85	+	+	36	0	0	48	0	0	4	0	0
After 45 minutes,	416	0	+	5	0	0	10	0	0	5	0	0
After 1 hour,	43	+	+	4	0	0	9	0	0	1	0	0
After 1½ hours,	11	0	+	5	0	0	21	0	0	8	0	0
After 2 hours,	5	0	0	9	0	0	22	0	0	2	0	0
After 3 hours,	4	0	0	4	0	0	10	0	0	13	0	+
After 4 hours,	5	0	+	4	0	0	5	0	0	3	0	0
After 5 hours,	6	0	+	3	0	0	2	0	0	8	0	0
After 6 hours,	0	0	0	5	0	0	15	0	0	1	0	0
After 7 hours,	1	0	0	5	0	0	12	0	0	5	0	0
After 8 hours,	3	0	+	-	0	0	3	0	0	10	0	+
After 24 hours,	2	0	0	3	-	-	1	0	0	6	0	0
Average,	43	-	-	11	-	-	115	-	-	7	-	-
Per cent. of samples tested which contained B. coli,	-	14.3	57.1	-	0.0	0.0	-	0.0	0.0	-	0.0	14.3

Series on Filter No. 216 — Continued.

	Sept. 15, 1903. Intended Rate, 50,000,000 Gallons per Acre Daily. Coagulant per Gallon, $1\frac{1}{2}$ Grains.			Sept. 17, 1903. Intended Rate, 50,000,000 Gallons per Acre Daily. Coagulant per Gallon, $1\frac{5}{8}$ Grains.			Sept. 22, 1903. Intended Rate, 50,000,000 Gallons per Acre Daily. Coagulant per Gallon, $1\frac{3}{4}$ Grains.			Sept. 24, 1903. Intended Rate, 50,000,000 Gallons per Acre Daily. Coagulant per Gallon, $1\frac{7}{8}$ Grains.		
	Bacteria per Cubic Centimeter.	B. coli.		Bacteria per Cubic Centimeter.	B. coli.		Bacteria per Cubic Centimeter.	B. coli.		Bacteria per Cubic Centimeter.	B. coli.	
		1 c.c.	100 c.c.		1 c.c.	100 c.c.		1 c.c.	100 c.c.		1 c.c.	100 c.c.
At start,	9	0	0	30	+	+	23	0	0	26	0	0
After 15 minutes,	2	0	+	500	+	+	16	0	+	3	0	+
After 30 minutes,	7	0	0	240	+	+	20	0	+	1	0	+
After 45 minutes,	4	0	0	550	+	0	21	0	+	2	0	0
After 1 hour,	2	0	+	425	0	0	15	0	+	3	0	0
After $1\frac{1}{2}$ hours,	2	0	0	65	+	+	1	0	+	6	0	0
After 2 hours,	2	0	0	9	0	0	3	0	0	3	0	0
After 3 hours,	1	0	0	3	0	0	0	0	0	2	0	0
After 4 hours,	2	0	0	1	0	+	1	0	0	0	0	0
After 5 hours,	1	0	0	3	0	+	5	0	0	1	0	0
After 6 hours,	3	0	0	12	0	0	0	0	0	1	0	0
After 7 hours,	3	0	0	425	+	+	-	0	0	1	0	0
After 8 hours,	3	0	0	105	+	+	-	-	-	-	-	-
After 24 hours,	4	0	0	190	+	0	1	0	0	2	0	+
Average,	3	-	-	183	-	-	9	-	-	4	-	-
Per cent. of samples tested which contained B. coli,	-	0.0	14.3	-	57.1	57.1	-	0.0	38.5	-	0.0	23.1

Series on Filter No. 216 — Continued.

	Sept. 29, 1903. Intended Rate, 50,000,000 Gallons per Acre Daily. Coagulant per Gallon, 2 Grains.			Oct. 1, 1903. Intended Rate, 50,000,000 Gallons per Acre Daily. Coagulant per Gallon, $1\frac{5}{8}$ Grains.			Oct. 5, 1903. Intended Rate, 50,000,000 Gallons per Acre Daily. Coagulant per Gallon, $1\frac{5}{8}$ Grains.		
	Bacteria per Cubic Centimeter.	B. coli.		Bacteria per Cubic Centimeter.	B. coli.		Bacteria per Cubic Centimeter.	B. coli.	
		1 c.c.	100 c.c.		1 c.c.	100 c.c.		1 c.c.	100 c.c.
At start,	25	0	0	31	0	0	12	0	0
After 15 minutes,	0	0	0	1	0	0	40	0	+
After 30 minutes,	1	0	0	2	0	0	130	0	0
After 45 minutes,	0	0	0	3	0	0	102	+	0
After 1 hour,	0	0	0	4	0	0	80	0	0
After $1\frac{1}{2}$ hours,	0	0	0	3	0	0	28	0	0
After 2 hours,	0	0	0	2	0	0	1	0	0
After 3 hours,	0	0	0	1	0	0	12	0	0
After 4 hours,	1	0	0	1	0	0	3	0	0
After 5 hours,	2	0	0	2	0	0	1	0	0
After 6 hours,	1	0	0	2	0	0	5	0	0
After 7 hours,	1	0	0	6	0	0	0	0	0
After 24 hours,	0	0	0	5	0	0	1	0	0
Average,	2	-	-	5	-	-	32	-	-
Per cent. of samples tested which contained B. coli,	-	0.0	0.0	-	0.0	0.0	-	7.7	7.7

Series on Filter No. 216 — Concluded.

	Oct. 9, 1903. Intended Rate, 50,000,000 Gallons per Acre Daily. Coagulant per Gallon, 1 Grain.			Oct. 13, 1903. Intended Rate, 50,000,000 Gallons per Acre Daily. Coagulant per Gallon, 7/8 Grain.			Oct. 15, 1903. Intended Rate, 50,000,000 Gallons per Acre Daily. Coagulant per Gallon, 3/4 Grain.		
	Bacteria per Cubic Centimeter.	B. coli.		Bacteria per Cubic Centimeter.	B. coli.		Bacteria per Cubic Centimeter.	B. coli.	
		1 c.c.	100 c.c.		1 c.c.	100 c.c.		1 c.c.	100 c.c.
At start,	125	0	0	95	0	0	90	0	0
After 15 minutes,	1,300	0	+	20	0	0	20	0	0
After 30 minutes,	1,900	0	+	38	0	0	28	0	0
After 45 minutes,	1,100	0	+	10	0	0	55	0	0
After 1 hour,	2,800	+	0	18	0	0	50	+	0
After 1½ hours,	700	+	0	6	0	0	80	0	0
After 2 hours,	200	0	0	20	0	0	7	0	0
After 3 hours,	85	0	0	2	0	0	7	0	0
After 4 hours,	75	0	0	4	0	0	4	0	0
After 5 hours,	26	0	0	13	0	0	1	0	0
After 6 hours,	42	0	0	12	0	0	3	0	0
After 7 hours,	4	0	0	6	0	0	5	0	0
After 24 hours,	3	0	0	1	0	0	150	+	0
Average,	643	-	-	19	-	-	38	-	-
Per cent. of samples tested which contained B. coli,	-	15.4	23.1	-	0.0	0.0	-	15.4	0.0

Chemical Results of Filter No. 216.

During the entire period of operation of this filter, in 1903, frequent chemical analyses of its effluent were made. The water applied to it was the usual Merrimack River water taken from the Essex Company's canal, and average analyses of this water are given on page 278.

Comparing the analyses of the applied water and of the effluent of this filter, as shown in a following table, and also the analyses of the effluent of sand Filter No. 8 A (see page 282), operating at a rate of about 4,000,000 gallons per acre daily, the following facts are noticed.

The average rate of filtration of Filter No. 216 was 29,000,000 gallons per acre daily.

The average color of the canal water during the period of operation of Filter No. 216 was 0.47; of the effluent of Filter No. 8 A during this period, 0.27; and that of the effluent of Filter No. 216 varied from 0.31 to 0.03, being practically colorless when from 1½ grains to 2 grains of coagulant per gallon were used.

The free ammonia in the effluent of Filter No. 8 A was only 9 per cent. of the free ammonia in the river water, while the effluent of Filter No. 216 contained 89 per cent. as much free ammonia as the river water. The albuminoid ammonia in the effluent of Filter No. 8 A was 44 per cent. of that in the river water, and the albuminoid ammonia in the effluent of Filter No. 216 was 43 per cent. of that in the river water. The oxygen consumed by the effluent of Filter No. 216 was practically one-half that consumed by the effluent of Filter No. 8 A.

Chemical Analyses of Effluent of Filter No. 216.

[Parts per 100,000.]

1903.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.
			Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
May,	35,491,700*	-	-	-	-	-	-	-	-	-	-
June,	24,396,800	65	None.	.31	.0086	.0136	.28	.011	.0002	.38	84.2
July,	22,778,100	72	None.	.16	.0114	.0101	.27	.014	.0000	.25	82.1
August,	24,997,000	69	None.	.07	.0104	.0082	.30	.017	.0000	.15	69.2
September,	33,226,800	67	None.	.03	.0163	.0063	.40	.016	.0002	.10	78.7
October,	33,100,000	60	None.	.04	.0101	.0056	.38	.015	.0004	.15	91.8
Average,	28,998,400	67	-	.12	.0115	.0088	.33	.015	.0002	.21	81.2

* Operated 6 days.

EXAMINATION OF SEWER OUTLETS

AND THE

EFFECT OF SEWAGE DISPOSAL, 1903.

EXAMINATION OF SEWER OUTLETS AND THE EFFECT OF SEWAGE DISPOSAL, 1903.

The legislation requiring the annual examination of the outlets of all main sewers and drains in the Commonwealth, and of the effect of sewage disposal, was enacted in the year 1901, and in the same year an act was passed to regulate the taking of shellfish from polluted flats and waters. The first examinations of outlets of sewers were directed to the outlets into the sea, by which flats or tidal waters from which shellfish are taken for food were liable to be contaminated, and the results of the first of these investigations made in the year 1901 may be found in the annual report for that year and in House Document No. 336, dated May 20, 1902.

In the year 1902 the outlets into the sea and into the various rivers and other inland waters were examined, and the results are presented in the annual report for that year.

During the year 1903 the examinations of sewer outlets have been directed especially to the effect of sewage disposal at those places in which works are in use for treating the sewage in order to prevent the pollution of streams or other objectionable conditions, and the results of the examinations are presented herewith.

Of the 92 cities and towns in the State having systems of sewerage 4 cities and 19 towns employ some form of treatment for the removal of organic matter from the sewage. In some of these places the quantity of organic matter removed from the sewage represents a small proportion of the total volume of organic matter in the sewage, but in a large proportion of these places the sewage treated is efficiently purified so that the resulting effluents, when discharged into a stream, do not noticeably affect its appearance or odor.

A list of those cities and towns which maintain works for the purification of their sewage is presented in the following table: —

Amherst.	Gardner.	Natick.
Andover.	Hopedale.	Pittsfield.
Billerica.	Leicester.	Southbridge.
Brockton.	Lenox.	Spencer.
Clinton.	Longmeadow.	Stockbridge.
Concord.	Marlborough.	Westborough.
Framingham.	Maynard.	Worcester.
Franklin.	Medfield.	

In addition to the cities and towns which maintain sewage purification works a large number of public and private institutions of various kinds are provided with such works. Many of these places contain a population as great as some of the smaller towns, and the outlets of the sewers of these institutions have been examined in connection with the examinations of sewer outlets of cities and towns.

Of the works now in operation for the purification of the sewage of cities, towns and institutions, the oldest is the works at Medfield, constructed in 1886. A few small works were installed in earlier years, but none of them is now in use. The works at Medfield were designed primarily for the disposal of the sewage of a hat factory, but a few dwelling houses are also connected with the sewers. The first works for the disposal of the sewage of a town of considerable size were constructed at Framingham in 1889.

At practically all of the sewage-disposal works now in operation in Massachusetts the ultimate method of purifying the sewage is by intermittent filtration through gravel or sand, and soil of this character, well suited for the purification of sewage by intermittent filtration, is found commonly in nearly all parts of the State.

The ready availability of sand and gravel areas naturally adapted for the purification of sewage, the simplicity of the process and small cost of maintenance have made this method of purification the most advantageous for adoption in practically all the cases in which sewage purification works have been found necessary, and the resulting effluents turned into the streams have been satisfactory in all cases where the works are of sufficient capacity and have received proper care. The processes of preliminary treatment of sewage in use in the State are, however, many and quite varied, and the results of the practical operation of these various methods have been carefully examined since their inception.

In presenting the results of these examinations the cities and towns are taken up alphabetically, and a detailed description of the works and of the results of their operation is presented. A general summary of the results of the operation of these works is presented subsequently. The works at the smaller places (Amherst, Billerica, Franklin, Lenox, Longmeadow, Maynard and Medfield), and at the various institutions, present little of additional interest and have been omitted.

Andover.

Population in 1900, 6,813.

The town is situated within the water-shed of the Shawsheen River, about 4 miles above its junction with the Merrimack. The population is located chiefly in the three villages of Andover, Frye Village and Ballardvale, the last being situated in the southerly part of the town, about 2½ miles from the main village.

A public water supply was introduced in 1890 from Haggett's Pond in Andover, and at the end of the year 1903 there were 30.2 miles of water pipe and 958 service pipes in use in the town. The public water supply has been extended to all of the villages, and the average daily quantity of water used by the town in 1903 was 365,000 gallons, or 51 gallons per inhabitant.

Sewerage System.

The sewerage system was constructed in 1898 and is available to the inhabitants of the main village of Andover but has not been extended to the other villages. The sewage of the greater portion of the main village, located on the east side of the river, is collected in a system of pipe sewers and conveyed by gravity to a filtration area in the northerly portion of the town adjacent to the boundary line of the city of Lawrence and the east bank of the Shawsheen River, where it is purified by intermittent filtration after the removal of a portion of the solid matter by sedimentation. The sewage from the lower portion of the main village, located in the lower part of the valley near the river, cannot be taken to the filtration area by gravity, and the sewage of this area is collected in tanks near the river, whence it was intended that it should be pumped into the main sewer, but this sewage is frequently allowed to flow directly into the Shawsheen River from the tanks, contrary to the requirements of the plans approved by the State Board of Health.

The main sewer from the town to the filtration area crosses the valley of a tributary of the Shawsheen River in the form of an inverted siphon. There is a screen chamber at the upper end of this siphon, with screens to intercept objects which might tend to clog the siphon, and at the low point of the pipe small filter beds, having an aggregate area of 0.7 of an acre, have been constructed to receive the discharge from the siphon in case it should become necessary to empty it for any purpose.

The total length of sewers constructed to the end of 1903 was 10.75 miles, and 431 buildings had then been connected with the system, classified as follows: —

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Dwelling houses,	373	Laundries,	3
Business blocks,	16	Schoolhouses,	5
Dormitories,	10	Boarding houses,	9
Hotels and restaurants,	4	Miscellaneous,	4
Factories,	2		
Club houses,	2	Total buildings connected,	431
Public buildings,	3		

The estimated population contributing sewage at the end of 1903 was 3,600.

Quantity of Sewage.

The sewage is almost wholly domestic sewage, the only factory waste discharged into the sewers being the waste water from the washing of rubber in a rubber factory.

Great care was taken in the construction of the sewers to exclude leakage, and underdrains were laid beneath the main sewers to collect and remove the ground water which is discharged into local water courses. A measurement of the leakage of ground water into the sewers in the latter part of November, 1898, after 5.48 miles of pipe sewers from 6 to 15 inches in diameter had been laid, of which 4.9 miles were underdrained, and before any buildings had been connected with the sewers, showed a leakage of 32,500 gallons per day, or about 6,000 gallons per mile of sewer. There was no leakage whatever in 2.61 miles of this system, of which 2.54 miles, or 97 per cent., were underdrained. It is probable that the leakage has increased considerably since the house connections were made; nevertheless, the leakage into the system is evidently small.

No record of the quantity of sewage flowing in the sewers has been kept by the local authorities. Occasional measurements have been made by the State Board of Health, the results of which are as follows: —

Flow of Sewage at Andover.

	Rate of Flow in Gallons per 24 Hours.				Rate of Flow in Gallons per 24 Hours.		
	Mar. 24-25, 1902.	Feb 10, 1903.	Apr. 6-7, 1903.		Mar. 24-25, 1902.	Feb. 10, 1903.	Apr. 6-7, 1903.
8.00 P.M.,	108,670	-	328,700	9.00 A.M.,	139,280	-	263,190
9.00 P.M.,	103,700	-	132,700	10.00 A.M.,	186,100	-	326,000
10.00 P.M.,	94,140	-	164,670	11.00 A.M.,	142,570	-	326,000
11.00 P.M.,	93,600	-	139,600	12.00 M.,	169,970	-	245,000
12.00 Mid.,	83,910	-	151,170	1.00 P.M.,	148,580	-	307,000
1.00 A.M.,	79,650	-	135,830	2.00 P.M.,	191,910	-	245,000
2.00 A.M.,	75,970	-	128,760	3.00 P.M.,	196,500	171,000	206,000
3.00 A.M.,	73,600	-	134,560	4.00 P.M.,	130,000	131,000	245,000
4.00 A.M.,	75,210	-	140,520	5.00 P.M.,	122,860	-	185,000
5.00 A.M.,	87,100	-	141,600	6.00 P.M.,	118,620	-	306,000
6.00 A.M.,	104,940	-	148,480	7.00 P.M.,	113,640	-	317,350
7.00 A.M.,	150,940	-	137,590				
8.00 A.M.,	184,000	-	200,390	Average,	123,980	-	210,670

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The daily flow per inhabitant, etc., computed from the limited information thus far obtained, is shown in the following table: —

	Average Flow of Sewage (Gallons per Day).
Total flow,	125,000
Flow per inhabitant,	17
Flow per person connected with the sewers,	35
Flow per connection,	290
Flow per mile of sewer,	11,000

Treatment of the Sewage before Filtration.

The sewage, before entering the siphon leading to the filtration area, passes through a screen chamber 6 feet long and 4 feet wide, containing screens having an area of about 18 square feet, constructed of vertical iron rods 18 inches long and ½ an inch in diameter set 1 inch apart, the bottom of the screens being 1 foot below the bottom of the entering sewer. The screens are cleaned each week, the material removed being sufficient to fill a pail having a capacity of about 3 gallons.

After passing through the screens the sewage enters the inverted siphon, which consists of a 12-inch iron pipe 4,971 feet in length, through which the sewage flows continuously. This pipe holds 29,000 gallons of sewage, and, with sewage flowing continuously, assuming that there are no deposits in the pipe, the rate of flow is such as to change the sewage between four and seven times a day, or once in from three to six hours. At the low point in this pipe, where the small filter beds are situated, the pipe has on several occasions been opened but never emptied, and the flow from the siphon at such times has contained some very finely divided solid matter but no large objects.

The settling tank into which the sewage is received at the filtration area is 50 feet long, 8 feet wide and 4.5 feet deep and is covered by a roof. Its capacity is 13,500 gallons, and the sewage is from about one and one-half to three hours in passing through.

This settling tank is drawn off about once each month and the contents discharged upon two sludge beds having a combined area of 0.15 of an acre. When the solid matter on the surface of the sludge beds has become sufficiently dry it is raked up and removed to the town poor farm, where it is used as a fertilizer. The sewage from the settling tank flows into a dosing tank having a capacity of 5,000 gallons, which is provided with a siphon arranged to empty the tank automatically as soon as it fills. This

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siphon, however, is very irregular in its operation, frequently discharging before the dosing tank is full, while at other times it does not operate at all and the sewage flows continuously upon the filter beds.

Description of the Filter Beds.

The area purchased by the town for filtration purposes comprises 31.7 acres adjacent to the easterly side of the Boston & Maine Railroad and the Shawsheen River. The nearest highways are about a quarter of a mile from the filtration area, and there are a few houses scattered along these streets.

The contour of the filtration area is quite irregular, the land sloping from the north-westerly and south-easterly sides toward a small valley in the middle, tributary to the Shawsheen River, and the filter beds thus far constructed are located chiefly on the north-westerly side of the area and around the upper end of the valley. The material found upon this area varied greatly in character, some of it being very fine while in other places it was much coarser and excellent for filtration purposes. The finer materials were removed and only the coarser sand used in the construction of the filter beds, and in the preparation of the filter beds a very large portion of the material of which they are composed was handled, thus increasing very materially the cost of preparation.

There are twenty filter beds in all, exclusive of the sludge beds, which have a combined area of 3.65 acres, or about 0.18 of an acre each. The character of the material of which the filter beds are composed, as determined from samples collected from the middle of each of the beds in 1903, is shown in the following table of analyses: —

Analyses of Filtering Material of the Andover Filter Beds.

Depth Below Surface (Feet).	Effective Size (Millimeters).			Uniformity Coefficient.			Albuminoid Ammonia (Parts per 100,000).		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
Surface,	.15	.41	.08	7.9	16.7	2.6	21.08	43.35	5.46
0.25,	.16	.38	.09	7.9	17.1	2.2	18.85	40.77	2.51
0.50,	.15	.46	.07	8.0	18.7	2.0	10.97	29.70	1.50
1.00,	.16	.26	.08	7.7	20.8	2.3	5.60	13.15	1.49
2.00,	.20	.40	.10	8.3	15.5	3.0	6.50	10.35	4.74

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Underdrainage.

The filter beds are thoroughly underdrained with lines of tile pipes laid about 20 feet apart and at a depth of from 4 to 5 feet beneath the surface. The underdrains of thirteen of the beds discharge into a main underdrain which receives also the flow of the small brook passing through the bottom of the valley within the area. The remaining seven beds discharge through a separate outlet into this brook near its mouth, but there is no flow through the latter underdrain except at the time when sewage is being applied to the beds having tributary underdrains. The underdrainage collects in a pool near the lower end of the valley, whence it flows into the Shawsheen River.

Method of Operating the Filters.

Sewage is applied to the filter beds by means of pipes laid in the embankments between the beds, having outlets either at one corner, or, in a few cases, at one side of each bed. The dosing tank has a nominal capacity of 5,000 gallons, and when it discharges this amount the quantity is sufficient to flood one of the beds to a depth of one-third of an inch. The surfaces of the beds are somewhat uneven, however, owing to unequal settlement, and consequently the sewage is discharged unevenly over different parts of the beds, the lowest portions receiving the greater quantity of sewage.

As the sewage is applied to each bed at only one point, the portion of the bed near the outlet usually receives more sewage than the other portions, and this is particularly marked when sewage discharges continously through the failure of the automatic siphon to operate.

The usual custom in operating the beds is to apply the sewage to either two or three beds at the same time and to divert the flow to a different series of beds three times during twenty-four hours. When the beds are operated in this way the average dose is from 75,000 gallons to 120,000 gallons per acre per day during periods of low flow, and each bed receives a dose once in from two to four days. At times of high flow the dose is about twice as large. The average rate of filtration over the entire area is from 35,000 to 60,000 gallons per acre per day.

Very little solid matter collects upon the surfaces of the beds and this chiefly near the point at which the sewage is delivered or in low places on the beds, and a small amount of solid matter has been removed from such places.

During the summer the beds are planted with corn, and the only attention which their surfaces receive during this season is that which is necessary in the cultivation of the corn. The beds are furrowed generally in October and remain so throughout the winter. No change is made in the method of applying the sewage, and the sewage applied to the various beds flows through the bottoms of the furrows and sinks into the soil.

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The average temperature of the sewage as it flows upon the beds in winter is about 42° F. and the temperature of the effluent about 39° F. No difficulty has been experienced in operating the beds during the coldest weather, and at such times, often for many weeks, the beds are completely covered with ice and snow, and the sewage is nowhere visible unless within a very small radius about the outlet pipe. The winter temperature at Andover in cold months has reached an average daily minimum of 6.6° F. continuously for a period of two months, with minimum temperatures running as low as —23° F.

Character of the Sewage.

The sewage of Andover is an unusually strong domestic sewage, owing chiefly to the small quantity of leakage into the sewers. It is the strongest that has been found among those places maintaining purification works where there are no manufacturing wastes discharged into the sewers. The sewage changes greatly in character between the town and the filtration area as a result of its slow movement through the inverted siphon and the settling tank; the solid matters become broken up and very finely divided, the heavier portions being removed in the settling tank, so that the sewage discharged upon the filter beds passes quickly into the sand at all times, and very little matter accumulates upon the surface.

The sewage is very offensive in odor, and the effluent shows less thorough purification than at places where the sewage is discharged upon the filter beds in a fresher condition. The average character of the sewage, as shown by chemical analyses of monthly samples, is indicated in the following table: —

Yearly Averages of Chemical Examinations of Sewage from Andover.

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Oxygen Consumed.	
	Total Residue.			Loss on Ignition.			Free.	Albuminoid.				Unfiltered.	Filtered.
	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.		Total.	Dissolved.	Suspended.			
1900, . .	112.75	52.03	60.72	67.29	18.81	48.48	6.32	1.70	.62	1.08	11.47	14.15	5.63
1901, . .	51.73	39.77	11.96	26.82	17.62	9.20	6.22	0.91	.57	.34	6.84	7.93	5.65
1902, . .	81.42	31.42	50.00	47.32	15.02	32.30	5.16	1.07	.41	.66	5.91	7.83	3.66
1903, . .	46.65	36.32	10.33	24.39	15.77	8.62	4.82	0.68	.41	.27	7.00	4.90	3.33

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Character of the Effluent.

The effluent from these works, though quite thoroughly purified, contains usually a larger quantity of free ammonia than is found ordinarily in the effluent of sewage after passing through filters of this character. The yearly averages of analyses of monthly samples of the effluent are given in the following table: —

Yearly Averages of Chemical Examinations of Effluent from the Andover Sewage Purification Works.

[Parts per 100,000.]

Year.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
1900,	29.74	0.7455	.0425	6.51	1.0524	.0146	.71	6.2	.2780
1901,	29.02	1.2907	.0902	6.13	0.8558	.0269	.91	5.5	.1918
1902,	34.43	0.9550	.0570	6.23	1.4660	.0390	.61	6.0	.2190
1903,	26.07	1.1040	.0677	5.37	0.8325	.0161	.74	4.8	.3097

Purification effected by the Andover Sewage Filters.

From the results of the yearly averages of analyses of sewage and effluent given in the preceding tables the percentages of organic matters removed in the process of filtration, as represented by the free ammonia, albuminoid ammonia and oxygen consumed, have been calculated and are presented in the following table. Tables are also appended showing, in a similar way, the purification effected in the warmer months of the year from June to November, inclusive, and in the colder months from December to May, inclusive.

Purification effected by the Sewage Filters at Andover.

[Parts per 100,000.]

Year.	Free Ammonia. Sewage.	Free Ammonia. Effluent.	Free Ammonia. Per Cent. Removed.	Total Albuminoid Ammonia. Sewage.	Total Albuminoid Ammonia. Effluent.	Total Albuminoid Ammonia. Per Cent. Removed.	Oxygen Consumed. Sewage.	Oxygen Consumed. Effluent.	Oxygen Consumed. Per Cent. Removed.
1900,	6.32	0.7455	88.2	1.70	.0425	97.5	14.15	.71	95.0
1901,	6.22	1.2907	79.2	0.91	.0902	90.1	7.93	.91	88.5
1902,	5.16	0.9550	81.5	1.07	.0570	94.7	7.83	.61	92.2
1903,	4.82	1.1040	77.1	0.68	.0677	90.0	4.90	.74	84.9

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Purification effected by the Sewage Filters at Andover during the Summer Months (from June to November, inclusive) of Each Year.

[Parts per 100,000]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1900,	7.21	0.4224	94.1	1.47	.0260	98.2	11.00	.48	95.6
1901,	7.65	1.4200	81.4	1.14	.1023	91.0	9.02	.96	89.4
1902,	5.78	1.0033	82.5	1.20	.0552	95.4	7.97	.60	92.5
1903,	5.79	1.0983	81.0	0.62	.0455	92.7	4.97	.59	88.1

Purification effected by the Sewage Filters at Andover during the Winter Months (from December to May, inclusive) of Each Year.

1900,	5.73	1.1493	79.9	2.21	.0663	97.0	7.11	.96	86.5
1901,	4.92	1.0873	77.9	0.65	.0768	88.2	6.72	.83	87.6
1902,	4.21	1.0600	74.8	0.92	.0582	93.7	7.95	.63	92.1
1903,	3.47	0.9147	73.6	0.50	.0775	84.5	3.85	.82	78.7

As previously stated, the main underdrain from which the samples of effluent have been collected receives also the flow of a small brook which passes through the area, and at times there is considerable brook water mixed with the effluent. A calculated analysis of the effluent has been prepared in which allowance has been made for the effect of the brook water, and the following table gives the purification effected, using the calculated, instead of the actual, analysis of the effluent: —

Purification effected by the Sewage Filters at Andover as indicated by the Calculated Analyses of the Effluent.

[Parts per 100,000.]

Year	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1900,	6.32	1.3386	78.9	1.70	.0760	95.5	14.15	1.27	91.0
1901,	6.22	1.4445	76.8	0.91	.1010	88.9	7.93	1.02	87.1
1902,	5.16	0.9550	81.5	1.07	.0570	94.7	7.83	0.61	92.2
1903,	4.82	1.4545	69.8	0.68	.0892	86.9	4.90	0.97	80.2

The main underdrain contains at times a very abundant growth of organisms, — chiefly *Leptomitus*, — sufficient to fill a considerable portion of the pipe. The underdrainage which is discharged upon the ground collects in

a pool, as already stated, from which it flows to the river. The water in its course from the underdrains through the pool to the river contains great numbers of organisms of various kinds, such as are commonly found in ground waters when exposed to light, especially in those which, like sewage effluent, contain an abundance of food for such organisms.

Cost of the Works.

The cost of construction of the Andover filter beds was large on account of the uneven character of the area on which the filter beds were prepared and on account of the fact that all strata of fine material were removed, necessitating the handling of practically all of the material in the filter beds. The following is a summary of the cost up to the year 1903: —

	Total Cost.	Cost per Acre.
Land for filter beds (31.7 acres),	$1,700	$56 67
Filter beds (3.8 acres, including sludge beds),	17,649	4,644 00
Blow-off beds at low place in inverted siphon (0.7 of an acre).	1,775	2,535 00
Settling and flush tanks (combined capacity, 35,000 gallons),	1,033	-

The area required for the purification of the Andover sewage is doubtless much smaller than would have been necessary had it not been for the underdrainage of the main sewers and the great care taken in their construction to exclude surface water and leakage.

When it becomes necessary to enlarge this area additional land is available which is already controlled by the town. There has been no complaint of odor or other objectionable conditions arising from the filtration area.

Cost of Maintenance of the Filters.

The purification works are operated by one man, who is occupied ordinarily for only a part of his time upon the filter beds, but he is assisted at times when it is necessary to plow the beds. The cost of the maintenance of the filtration area has been practically constant from year to year. The cost for the year 1902 was $622.50 and for the year 1903, $638.25.

BROCKTON.

Population in 1900, 40,063.

The city of Brockton is situated in the valley of the Salisbury Plain River, one of the tributaries of the Taunton River, which flows through the city from north to south. The water-shed of the stream at a point near the lower end of the city has an area of about 16 square miles, which contains all of the thickly settled portions of the city of Brockton. Much of

the area upon which the city is built is nearly level, and the soil in many places contains large quantities of water.

A public water supply was introduced in 1880 from a storage reservoir constructed on a tributary of the Salisbury Plain River north of the city, from which it is supplied by pumping, and the distributing pipes have been extended throughout the thickly settled portion of the city. At the end of the year 1903 there were 85.8 miles of distributing mains in use, with which there were 5,849 connections. The average daily quantity of water used in 1903 was 1,473,000 gallons, equivalent to about 33 gallons per inhabitant.

Sewerage System.

The construction of a sewerage system was begun in 1893 and the works were completed in 1894. Sewage is collected by systems of pipe sewers into a main sewer constructed of brick masonry in the valley of the Salisbury Plain River, by which the sewage is conveyed to a reservoir and pumping station at the southerly end of the city, from which it is forced to a filtration area situated in the extreme south-westerly corner of the city adjacent to the towns of Easton and West Bridgewater, where it is purified by intermittent filtration and the effluent discharged into the head waters of the Coweeset River, another tributary of the Taunton.

At the end of the year 1903 the total length of sewers in use was 32.6 miles, of which 3 miles were brick sewers and 29.6 miles pipe sewers. At that time there were 1,714 buildings connected with the sewers which may be classified as follows: —

Buildings containing 1 family,	370
Buildings containing 2 families,	820
Buildings containing 3 families,	84
Buildings containing 4 families,	33
Buildings containing 5 families,	2
Buildings containing 6 families,	27
Buildings containing 8 families,	2
Buildings containing 9 families,	1
Buildings containing 12 families,	1
Buildings containing 16 families,	2
Buildings containing 18 families,	1
Buildings containing 24 families,	1
Business blocks,	96
Buildings containing stores, not called business blocks,	91
Factories,	59
Hotels and boarding houses,	53
Churches,	12
Schoolhouses,	9
Bakeries,	7
Railroad stations,	4

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Fire stations,	4
Club houses,	5
Car barns,	2
Police stations,	2
Court house,	1
Old Ladies' Home,	1
Emergency hospital,	1
Miscellaneous,	23
Total,	1,714

The total population contributing sewage at the end of the year 1903 is estimated to be about 25,000.

Quantity of Sewage.

There are many shoe factories in Brockton which discharge into the sewers small quantities of liquid wastes resulting from the soaking of leather; otherwise the sewage is chiefly domestic sewage, and surface water is carefully excluded from the sewers.

Great care was taken in the construction of the sewers to exclude also leakage, and underdrains were laid beneath the sewers in districts where large quantities of ground water were encountered, with outlets at convenient points into the nearest water course. The main sewer is laid at a level considerably below the surface of the water in the Salisbury Plain River, and at times of very high water the surface of the ground in the vicinity of the sewer is flooded. When the main sewer was completed, and before connections had been made with it, the amount of leakage was measured at a time when the water of the stream was low, and it was found that in a section of the sewer about 2,000 feet long immediately above the pumping station the leakage was at the rate of about 17,000 gallons per day, or at the rate of 45,000 gallons per mile of sewer. The leakage in the entire length of the main sewer at that time (10,400 feet) was about 120,000 gallons per day, or 61,000 gallons per mile of sewer. At a time of high water, when the meadows along the river were flooded, it was found that the leakage into the main sewer was about 350,000 gallons per day, or 178,000 gallons per mile of sewer. The size of the sewer at its lower end is 32 inches by 48 inches. This sewer was carefully constructed and an underdrain laid beneath it for the removal of ground water.

An examination of the records of the quantity of sewage received into the reservoir at Brockton shows that there is a large leakage into the sewers, the flow at times of very wet weather being about three times as great as during ordinary weather.

Records have been kept of the quantity of sewage pumped, and from these records the following table has been prepared: —

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Quantity of Sewage pumped at Brockton, in Thousand Gallons per Day.

Month.	1898.			1899.			1900.		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
January,	508	649	285	923	1,534	725	522	679	407
February,	783	2,441	478	783	984	574	981	1,723	492
March,	740	1,029	521	1,015	1,662	791	930	1,704	612
April,	736	1,464	548	749	1,060	543	532	672	454
May,	691	1,036	518	526	726	366	679	1,077	466
June,	575	792	467	364	425	301	892	1,390	489
July,	503	724	325	404	585	322	572	832	331
August,	704	937	451	382	484	312	629	851	405
September,	508	733	278	487	1,289	300	454	666	265
October,	595	853	391	616	1,043	436	597	978	385
November,	762	882	628	509	654	349	701	968	405
December,	768	934	693	422	569	319	714	1,171	556
Year,	656	2,441	278	598	1,662	300	683	1,723	265

Quantity of Sewage pumped at Brockton, in Thousand Gallons per Day — Concluded.

Month.	1901.			1902.			1903.		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
January,	635	794	522	979	1,681	763	967	1,255	782
February,	577	749	344	784	1,096	635	990	1,445	750
March,	964	2,097	569	1,265	1,548	967	1,369	1,617	992
April,	1,389	1,930	1,000	912	1,268	623	1,220	1,677	923
May,	1,124	1,789	777	672	879	555	732	956	555
June,	796	1,190	574	588	668	529	736	917	611
July,	648	784	506	563	696	459	722	894	576
August,	582	805	512	598	754	519	734	878	639
September,	538	632	433	598	718	398	689	809	555
October,	587	794	469	649	874	520	846	1,176	602
November,	566	850	464	610	864	463	769	880	572
December,	1,050	2,369	642	894	1,598	612	759	927	639
Year,	788	2,369	344	759	1,681	398	878	1,677	555

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The average, maximum and minimum quantity pumped per inhabitant, per person connected with the sewers, etc., in 1903 is shown in the following table: —

	Flow of Sewage (Gallons per Day).		
	Average.	Maximum.	Minimum.
Total flow,	878,000	1,677,000	555,000
Flow per inhabitant,	20	38	13
Flow per person connected with the sewers,	25	48	16
Flow per connection,	534	1,021	338
Flow per mile of sewer,	27,400	51,760	17,130

Treatment of the Sewage before Filtration.

The covered masonry reservoir into which the sewage is received at the pumping station is 118 feet long, 42 feet wide and contains a maximum depth of 12 feet of sewage. Its total capacity, including the storage in the main sewer, into which the sewage is backed up for a considerable distance when the reservoir is full, is 600,000 gallons. The reservoir is designed to hold the night flow of sewage, so that the pumps may be operated only during the daytime, but at times when the leakage into the sewers is large it has been the custom to permit a portion of the sewage to flow into the river, this overflow taking place chiefly at night and when there is a large flow in the stream. The quantity of sewage disposed of in this way in the year 1903 was a small percentage of the total flow.

As the sewage flows from the reservoir to the pumps it passes through screens constructed of iron plates having open spaces of $\frac{3}{4}$ of an inch between the plates. The screens have an area of 100 square feet, but are so arranged that as the sewage in the reservoir is drawn down the effective area of the screens is decreased. The screens require frequent cleaning when the pumps are in operation, the quantity of screenings removed in this way in 1903 amounting to about 185 pounds per day. The screenings are burned beneath the boilers.

In order to remove solid matter which may settle to the bottom of the reservoir a system of perforated pipes has been laid along the floor of the reservoir connected with the force main, so that sewage may be admitted to these pipes under pressure to stir up deposits in the bottom of the reservoir. When the depth of the sewage in the reservoir has been reduced by pumping to about 1 foot, sewage is discharged through the perforated pipes to stir up the solid matter, which then flows to the pumps. It has

not been necessary to clean the bottom of the reservoir, other than by the use of these pipes, since the works were constructed.

The pumping plant consists of two pumping engines, each of which has a capacity of 5,000,000 gallons in twenty-four hours. The pumps are provided with ordinary water valves, which require considerable attention in order to keep them clear of rags and other solid matter.

The force main from the pumping station to the filtration area is constructed of cast-iron pipe 24 inches in diameter and has a total length of 17,500 feet. The force main rises to a point within about 3,000 feet of the filtration area, and the elevation of this point is about 38 feet above the pumping station. Between this point and the filtration area there is a depression in the force main where it crosses the Coweeset River, and at this point a blow-off has been provided, but the blow-off has never been used. When the pumps are stopped all but about 1,500 feet of the pipe remains full. The force main contains, when full, about 411,000 gallons, which is about one-half the daily flow of sewage. When the pumps are operated at their normal rate the velocity through the force main is about 2.5 feet per second.

Description of the Filter Beds.

The area controlled by the city for sewage-disposal purposes comprises 38.7 acres, originally nearly level and containing soil naturally very well adapted to the purification of sewage by intermittent filtration. There is no population in the immediate neighborhood of the filtration area, the nearest house being about 750 feet distant. There are about 25 houses within half a mile of the area.

Upon this area 23 filter beds have been prepared, having a combined area of 21.48 acres. All but 4 of the beds were prepared by removing all of the loam and subsoil down to the sand and gravel lying beneath. The remaining 4 beds were prepared by the removal of the loam from the surface, but the subsoil was left in place.

A large number of test pits was dug previous to the construction of the filter beds, in order to determine the character of the filtering material, but no samples of soil have been examined since the beds were completed. The subsoil in general has an effective size of about 0.07 of a millimeter, and contains about 100 parts per 100,000 of albuminoid ammonia, while the effective size of the sand varies from 0.04 to 0.75 of a millimeter. The sand is stratified, but the different strata are not separated, in most cases, by a distinct line of stratification, and the material in general is coarse and porous. In ten of the beds a thin stratum of clay is found in the sand at a depth of from 7 to 8 feet beneath the surface of the bed.

Underdrainage.

In those beds where the soil was found to be coarse and porous no underdrains were laid, but where strata of fine sand or clay were found the beds were underdrained by lines of tile pipe laid about 30 feet apart.

The principal underdrain discharges into the Coweeset River, and the underdrain from a smaller portion of the area discharges into Daly Brook, a tributary of the Coweeset River, which flows along the northerly side of the beds. Sewage effluent also finds its way into Daly Brook at other points, and there are one or two considerable springs along the banks of this stream fed by effluent from the filter beds.

Method of Operating the Filters.

The filter beds are in charge of a chemist, who has a laboratory upon the grounds, and the operation of the filters is carefully supervised, with a view to obtaining the best practicable results.

The sewage which settles to the bottom of the reservoir, as already indicated, is taken into the pumps during the last portion of each day's pumping, and remains in the force main until pumping is resumed on the following day. When this heavier sewage is received at the filtration area it is generally diverted to one of 4 beds which are reserved for the disposal of this sewage. The remaining lighter sewage is discharged upon the remaining beds in carefully regulated doses, the quantity applied to each bed being regulated with a view to securing the most efficient purification at all times. The sewage is delivered to the beds at such a rapid rate that the application of sewage to a bed requires ordinarily about thirty minutes.

The sewage is applied to the beds by means of carriers extending across the middle of each of the beds. The carriers are channels constructed with concrete bottoms, the level of which is slightly above the level of the beds, and with wooden sides about 12 inches high, through which there are openings at distances of about 40 feet. At each opening the cross-section of the carrier is reduced by bringing the sides nearer together. By means of this carrier the sizes of the openings can be regulated so that practically an equal quantity of sewage can be discharged at each opening, and this method of applying the sewage to the beds has operated very satisfactorily.

During the year 1903 the average quantity of heavy sewage received at the filtration area was 86,200 gallons per day, nearly all of which was applied to the 4 beds reserved for the reception of this sewage.

These beds have required cleaning after receiving an average of twenty-three doses, the quantity of material removed from the surfaces amounting

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during the year to 1,852 tons of dry material. This sludge is sold to farmers, and during 1903 the city received $150 for this material.

The remaining filter beds, which receive the lighter sewage, require very little care, and practically no material, excepting weeds and grass, is removed from them. Some of these beds are planted with corn each year, and experiments have been made with other crops, including peas and sunflowers. Corn, however, appears to be the most satisfactory crop that can be raised, all things considered, and a small sum may be realized from it in cases when it is not necessary to apply a large quantity of sewage to the filter beds.

In the fall the surfaces of the beds are arranged in furrows and ridges, and during the winter no difficulty is experienced in the disposal of the sewage. The ice and snow collecting upon the beds rest upon the ridges, and the sewage finds its way readily into the furrows and disappears.

Records of the temperature of the sewage as it is received at the pumping station and as it is discharged upon the filter beds, together with the temperature of the effluent in the underdrains, for the year 1903, are given in the following table: —

Month.	Temperature (Degrees F.).		
	Sewage at Reservoir.	Sewage at Filter Beds.	Effluent.
January,	48.0	47.8	44.6
February,	44.7	45.8	41.4
March,	46.2	47.5	40.9
April,	49.5	50.0	44.0
May,	54.2	53.6	47.7
June,	58.1	57.2	51.7
July,	59.0	60.0	54.8
August,	59.8	61.9	58.8
September,	60.4	62.0	60.3
October,	59.9	59.3	59.5
November,	56.3	54.8	54.1
December,	51.4	49.7	47.6
Average,	54.0	54.4	50.4

Careful records have been kept of the quantity of sewage applied to each of the filter beds, and the average quantity applied during the years 1902–03 is given in the following table: —

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Quantity of Sewage applied to Brockton Filter Beds.

NUMBER OF BED.	Area (Acres).	Number of Doses of Ordinary Sewage.	Average Size of Dose of Ordinary Sewage (Gallons).	Maximum Size of Dose of Ordinary Sewage (Gallons).	Average Daily Quantity of Ordinary Sewage applied (Gallons).	Number of Doses of Heavy Sewage.	Average Size of Dose of Heavy Sewage (Gallons).	Average Daily Quantity of Heavy Sewage applied (Gallons).	Total Daily Quantity applied (Gallons).	Total Daily Quantity applied (Gallons per Acre).
1902.										
1,	1.01	4	145,400	256,300	1,600	85	90,400	21,100	22,700	22,500
2,	1.05	20	162,700	312,800	8,900	87	88,400	21,100	30,000	28,600
3,	0.95	18	129,400	194,000	6,400	90	87,800	21,600	28,000	29,500
4,	1.00	79	88,800	161,400	19,200	43	91,700	10,800	30,000	30,000
5,	0.99	110	103,700	146,300	31,300	-	-	-	31,300	31,600
6,	0.99	138	102,500	300,000	38,800	-	-	-	38,800	39,200
7,	0.99	126	98,400	153,400	34,000	-	-	-	34,000	34,300
8,	0.93	168	94,400	142,900	43,400	-	-	-	43,400	46,600
9,	0.97	101	82,400	117,200	22,800	-	-	-	22,800	23,500
10,	0.98	152	76,200	215,900	31,700	-	-	-	31,700	32,300
11,	0.99	118	78,100	105,500	25,200	-	-	-	25,200	25,500
12,	0.98	98	75,500	108,000	20,300	-	-	-	20,300	20,700
13,	0.87	163	74,000	255,600	33,000	-	-	-	33,000	37,900
14,	0.99	105	113,600	274,500	32,700	12	91,900	3,000	35,700	36,100
15,	0.99	108	117,600	237,500	34,800	30	78,400	6,400	41,200	41,600
16,	0.89	136	124,800	185,200	46,500	-	-	-	46,500	52,200
17,	0.97	123	120,700	191,000	40,700	-	-	-	40,700	41,900
18,	0.98	133	137,700	217,100	50,200	-	-	-	50,200	51,200
19,	0.89	121	131,000	201,700	43,400	-	-	-	43,400	48,800
20,	0.97	137	124,000	230,300	46,600	-	-	-	46,600	48,000
21,	0.70	97	92,900	157,400	24,700	-	-	-	24,700	35,300
22,	0.41	3	154,500	183,200	1,300	-	-	-	1,300	3,200
23,	0.99	24	170,200	555,900	11,200	-	-	-	11,200	11,300
1903.										
1,	1.01	35	26,800	89,400	2,600	98	89,700	24,100	26,700	26,400
2,	1.05	45	30,000	89,700	3,700	96	88,200	23,200	26,900	25,600
3,	0.95	33	37,400	98,400	3,400	97	86,700	23,000	26,400	27,800
4,	1.00	40	52,000	142,700	5,700	60	90,800	14,900	20,600	20,600
5,	0.99	89	108,600	213,000	26,500	1	65,100	200	26,700	27,000
6,	0.99	125	110,800	325,500	38,000	-	-	-	38,000	38,400
7,	0.99	102	98,300	173,600	27,500	-	-	-	27,500	27,800
8,	0.93	148	108,400	259,500	44,000	1	88,800	200	44,200	47,500
9,	0.97	224	82,200	129,400	50,400	-	-	-	50,400	52,000
10,	0.98	220	84,300	129,100	50,800	-	-	-	50,800	51,800
11,	0.99	214	87,000	111,900	51,000	2	94,100	500	51,500	52,000
12,	0.98	216	84,800	111,900	50,200	1	92,600	300	50,500	51,500
13,	0.87	206	81,300	142,100	45,900	2	79,700	400	46,300	53,200
14,	0.99	110	125,900	226,300	37,900	-	-	-	37,900	38,300
15,	0.99	152	118,600	330,800	49,400	-	-	-	49,400	50,000
16,	0.89	128	110,200	234,300	38,700	-	-	-	38,700	43,500
17,	0.97	149	113,300	195,700	46,300	-	-	-	46,300	47,700
18,	0.98	162	113,200	212,400	50,300	-	-	-	50,300	51,300
19,	0.89	150	118,500	288,300	48,700	-	-	-	48,700	54,700
20,	0.97	127	117,000	190,600	40,700	-	-	-	40,700	42,000
21,	0.70	146	104,600	209,300	41,800	-	-	-	41,800	59,700
22,	0.41	25	126,700	259,900	8,700	-	-	-	8,700	21,200
23,	0.99	72	169,500	457,700	33,400	-	-	-	33,400	33,700

Character of the Sewage.

As already indicated, the sewage of Brockton is chiefly a domestic sewage containing, however, a considerable quantity of manufacturing waste derived from shoe factories. It is also greatly diluted at times by leakage into the sewers. The sewage delivered at the filtration area varies greatly

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in strength during the day, and the heavier portions are disposed of upon a set of beds used especially for this purpose.

The average character of the lighter sewage and of the heavier sewage applied to the sludge beds, as shown by chemical analyses, is presented in the following tables. A careful estimate has been made of the quantity of light and heavy sewage discharged at the filtration area each day, and from this estimate and the results of the analyses it is practicable to calculate average analyses of the sewage, and such calculated analyses have been used in preparing the tables on pages 325 and 326 which show the purification effected.

Yearly Averages of Chemical Examinations of Sewage from Brockton

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Oxygen Consumed.	
	Total Residue.			Loss on Ignition.			Free.	Albuminoid.					
	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.		Total.	Dis-solved.	Sus-pended.		Unfiltered.	Filtered.
1897	39.15	29.32	9.83	18.40	10.41	7.99	2.36	0.57	0.33	0.24	6.29	3.67	1.99
1898	45.63	31.47	14.16	23.15	11.70	11.45	3.12	1.05	0.34	0.71	6.59	4.90	2.90
1899	48.27	38.17	10.10	22.17	13.89	8.28	3.51	0.65	0.41	0.24	8.30	8.07	5.04
1900	56.95	43.93	13.02	27.37	16.43	10.94	3.88	0.71	0.43	0.28	9.04	11.07	7.37
1901	63.35	51.13	12.22	32.73	22.25	10.48	4.98	0.90	0.48	0.42	10.22	11.50	8.77
1902	72.02	53.33	18.69	34.92	22.15	12.77	4.74	0.91	0.50	0.41	10.90	13.02	8.84
1903	81.88	62.42	19.46	42.52	25.18	17.34	5.21	0.96	0.50	0.46	13.18	16.27	9.20

Yearly Averages of Chemical Examinations of Sludge from the Bottom of Sewage Reservoir at Brockton.

1897	234.00	36.49	197.51	167.11	15.47	151.64	4.41	3.76	0.82	2.94	6.82	24.69	3.53
1898	253.00	34.75	218.25	188.96	15.09	173.87	4.35	4.25	0.57	3.68	5.88	33.19	3.51
1899	263.20	46.08	217.12	182.65	19.28	163.37	4.72	3.97	0.52	3.45	8.62	36.63	5.72
1900	270.17	48.60	221.57	189.48	19.77	169.71	4.79	4.38	0.52	3.86	8.81	35.98	6.97
1901	509.75	62.97	446.78	401.65	30.22	371.43	6.11	5.21	1.06	4.15	10.40	34.87	11.17
1902	377.43	65.07	312.36	297.73	29.00	268.73	6.56	5.61	0.65	4.96	12.68	48.01	11.87
1903	472.92	69.02	403.90	374.42	27.32	347.10	6.19	7.05	0.60	6.45	13.90	71.38	10.80

Character of the Effluent.

Part of the effluent from the Brockton filtration area discharges through a main underdrain into the Coweeset River and part through a smaller underdrain into Daly Brook, while an additional quantity finds its way directly into the brook. Regular analyses of samples of effluent from the

main underdrain discharging into the Coweeset River have been made monthly for several years, and the results are presented in the following table: —

Yearly Averages of Chemical Examinations of the Effluent from the Pearl Street Underdrain.

[Parts per 100,000.]

Year.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
1897,	27.75	.0911	.0105	4.80	1.2245	.0016	.11	7.4	.0003
1898,	28.68	.1766	.0123	4.88	1.7292	.0012	.13	6.7	.0023
1899,	33.71	.1321	.0105	7.08	1.6371	.0039	.16	6.9	.0040
1900,	34.72	.1577	.0133	7.83	2.1227	.0100	.19	6.3	.0062
1901,	40.36	.0824	.0089	9.23	2.2017	.0057	.13	3.2	.0089
1902,	48.30	.1633	.0163	10.42	3.1667	.0056	.17	5.9	.0092
1903,	53.17	.2250	.0166	11.13	3.0750	.0103	.33	3.6	.0601

Purification effected by the Brockton Sewage Filters.

From the results of the yearly averages of analyses of sewage and effluent, the percentages of organic matters removed from the sewage, as shown by the free ammonia, albuminoid ammonia and oxygen consumed, have been calculated and are presented in the following table. Tables are also appended showing, in a similar way, the purification effected in the six warmer months of the year, from June to November, inclusive, and in the six colder months, from December to May, inclusive. A table is also appended showing the calculated analyses of the effluent, making allowance for the presence of a considerable quantity of ground water from the filtration area and its neighborhood, which finds its way into the underdrains. In these tables the calculated analyses of sewage are used, the calculations being made from the estimate of the quantity of light and heavy sewage discharged at the filtration area each day.

Purification effected by the Sewage Filters at Brockton.

[Parts per 100,000.]

Year.	Free Ammonia. Sewage.	Free Ammonia. Effluent.	Free Ammonia. Per Cent. Removed.	Total Albuminoid Ammonia. Sewage.	Total Albuminoid Ammonia. Effluent.	Total Albuminoid Ammonia. Per Cent. Removed.	Oxygen Consumed. Sewage.	Oxygen Consumed. Effluent.	Oxygen Consumed. Per Cent. Removed.
1898,	3.01	.1766	94.1	1.36	.0123	99.1	6.44	.13	98.0
1899,	3.66	.1321	96.4	1.02	.0105	99.0	11.39	.16	98.6
1900,	3.99	.1577	96.0	1.12	.0133	98.8	13.76	.19	98.6
1901,	5.14	.0824	98.4	1.48	.0089	99.4	14.79	.13	99.1
1902,	5.01	.1633	96.7	1.52	.0163	98.9	17.75	.17	99.0
1903,	5.32	.2250	95.8	1.57	.0166	98.9	21.85	.33	98.5

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Purification effected by the Sewage Filters at Brockton during the Summer Months (from June to November, inclusive) of Each Year.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1898,	2.88	.0227	99.2	0.78	.0086	98.9	6.43	.12	98.1
1899,	4.06	.0464	98.9	1.07	.0087	99.2	13.44	.15	98.9
1900,	4.12	.0365	99.1	1.24	.0097	99.2	15.11	.11	99.3
1901,	5.57	.0489	99.1	1.76	.0079	99.5	18.13	.13	99.3
1902,	5.69	.0827	98.5	1.74	.0220	98.7	18.16	.20	98.9
1903,	5.65	.1410	97.5	1.65	.0158	99.0	22.47	.28	98.8

Purification effected by the Sewage Filters at Brockton during the Winter Months (from December to May, inclusive) of Each Year.

1898,	3.36	.3365	90.0	0.89	.0166	98.1	6.54	.13	98.0
1899,	2.63	.2084	92.1	0.85	.0112	98.7	7.90	.16	98.0
1900,	4.24	.2927	93.1	1.07	.0160	98.5	13.47	.27	98.0
1901,	4.44	.1025	97.7	1.09	.0122	98.9	10.32	.14	98.6
1902,	4.22	.2450	94.2	1.37	.0103	99.2	17.29	.13	99.2
1903,	4.81	.2970	93.8	1.42	.0166	98.8	20.21	.36	98.2

Purification effected by the Sewage Filters at Brockton, as shown by the Calculated Analyses of the Effluent.

1899,	3.66	.1561	95.7	1.02	.0124	98.8	11.39	.19	98.3
1900,	3.99	.1827	95.4	1.12	.0154	98.6	13.76	.22	98.4
1901,	5.14	.0921	98.2	1.48	.0099	99.3	14.79	.15	99.0
1902,	5.01	.1752	96.5	1.52	.0175	98.8	17.75	.18	99.0
1903,	5.32	.2695	94.9	1.57	.0199	98.7	21.85	.40	98.2

Cost of the Works.

The cost of the purification works, as presented in the reports of the sewer commissioners and city engineer, is shown in the following table: —

Land for filtration area (38.7 acres),	$9,234 00
Preparing filtration area,	50,301 97
Force main,	74,988 93
Reservoir,	29,863 59
Pumping station and machinery,	44,588 57

BROCKTON.

Cost of Maintenance of the Filters.

The annual cost of maintenance of the filter beds (exclusive of improvements), as shown in the printed reports of the sewer department, is as follows: —

Year.	Cost.	Year.	Cost.
1896,	$2,195 21	1900,	$2,343 80
1897,	2,156 47	1901,	2,677 51
1898,	2,282 72	1902,	2,666 24
1899,	2,494 06	1903,	3,537 68

NOTE. — In 1900 the hours of labor were reduced, the wages remaining the same, and in 1903 the wages of the laborers were increased to $2.25 per day of 8 hours.

The annual receipts from the sale of the crops and sludge raked from the surfaces of the sludge beds have been as follows: —

Year.	Crops.	Sludge.	Total.
1896,	$273 51	-	$273 51
1897,	289 86	-	289 86
1898,	250 62	-	250 62
1899,	302 50	-	302 50
1900,	328 66	$125 00	453 66
1901,	80 00	150 00	230 00
1902,	116 00	150 00	266 00
1903,*	-	150 00	150 00

* No crops were grown during this year.

CLINTON.

Population in 1900, 13,667.

The town of Clinton is situated in the water-shed of the south branch of the Nashua River a short distance below the Wachusett reservoir, at present under construction on this stream for the water supply of the metropolitan district, and about a mile above the confluence of the south and north branches of the Nashua River. Coachlace Brook, a small tributary of the south branch of the Nashua River, flows through the northerly portion of the town. The town has a very small area, the greater portion of which is thickly populated.

A public water supply was introduced into the town in 1882 from small streams and reservoirs in Sterling, from which all of the water is supplied by gravity. At the end of the year 1903 there were 34.4 miles of water pipes in use, with which there were 1,743 connections.

Since 1896 the quantity of water supplied to the town has been metered, and from the meter records it appears that the quantity used in 1903 was 578,000 gallons per day, equivalent to about 39 gallons per inhabitant.

CLINTON.

Sewerage System.

The first sewers in Clinton were constructed many years ago and discharged originally into the river or into tributary streams at convenient points. Storm water as well as sewage was admitted to the original sewers, but subsequently a separate system of sewers was constructed with two principal outlets into the river, and storm water was excluded.

Under the provisions of the metropolitan water act of 1895 a system of sewage disposal was constructed in 1898–99 and has since been operated by the Metropolitan Water Board.

The sewerage system of the town of Clinton at the present time consists of systems of pipe sewers which discharge the sewage into a main intercepting sewer, through which it flows to a reservoir and pumping station near the south branch of the Nashua River east of the town, from which it is pumped to filter beds in the town of Lancaster and there purified by intermittent filtration, the effluent flowing through a small stream to the south branch of the Nashua River just above its confluence with the north branch.

The total length of sewers constructed at the end of the year 1903 was 19.2 miles, with which there were 1,486 connections. The estimated population contributing sewage at the end of the year 1903 was 10,000. The sewers have been extended throughout practically all of the built-up section of the town.

Quantity of Sewage.

The quantity of sewage pumped to the Clinton filtration area during the last four years, as shown by the pumping records, is given in the following table: —

Quantity of Sewage pumped, in Thousand Gallons per Day.

Month.	1900.			1901.			1902.			1903.		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
January,	568	731	325	626	778	400	1,006	1,374	637	932	1,246	575
February,	818	1,234	411	561	670	378	722	1,213	486	1,013	1,264	606
March,	858	1,222	473	780	1,309	411	1,285	1,348	763	1,170	1,262	780
April,	694	1,106	423	1,256	1,397	793	1,088	1,335	626	1,148	1,294	671
May,	732	1,145	480	1,223	1,429	818	782	1,186	508	628	916	377
June,	489	771	303	873	1,434	491	594	727	368	872	1,632	374
July,	460	607	178	658	938	387	563	655	324	784	1,425	484
August,	494	690	333	632	794	448	560	705	357	600	735	359
September,	478	595	296	693	1,200	428	590	660	337	546	652	354
October,	518	609	303	868	1,189	549	705	1,124	387	563	695	389
November,	603	1,128	286	854	1,208	567	671	851	456	551	728	376
December,	822	1,300	469	1,009	1,353	477	898	1,364	487	611	887	366
Year,	627	1,300	178	836	1,434	378	784	1,374	324	785	1,632	354

CLINTON.

The average, maximum and minimum daily flow per inhabitant, etc., for the year 1903 are given in the following table: —

	Gallons per Day.		
	Average.	Maximum.	Minimum.
Total flow,	785,000	1,632,000	354,000
Flow per inhabitant,	58	109	24
Flow per person connected with the sewers,	78	163	35
Flow per connection,	528	1,098	238
Flow per mile of sewer,	40,910	85,040	18,540

The sewage of Clinton is the strongest delivered at any purification works in Massachusetts, its great strength being caused chiefly by the discharge into the sewers of the wool-scouring waste from the Bigelow carpet works. The quantity of wool scoured at this works amounts to about 25,000 pounds per day, and in the process of scouring the wool loses about 50 per cent. of its weight. About 75,000 gallons of water are used per day in the process. The wastes contain an enormous quantity of solid matter, and, in order to remove a portion of it before its discharge into the sewers, two settling tanks have been constructed at the works, each of which is 35 feet long, 8 feet wide and 3.7 feet deep, so that each contains about 7,750 gallons. The wastes are about an hour, on an average, in passing through one of the tanks. The tanks are cleaned out once each week, when there is usually a deposit of from 17 to 22 inches in depth of solid matter in the bottom of the tanks.

Several observations have been made of the operation of these tanks, and several series of samples of the liquor entering and leaving the tanks have been collected for analysis. The results of these analyses are given in the following table: —

CLINTON.

Chemical Examinations of Wool-scouring Wastes from Bigelow Carpet Works before and after passing through Settling Tank.

Inlet to Tank.

[Parts per 100,000.]

Number.	Date of Collection.	Residue on Evaporation.						Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		Fats.	
		Total Residue.			Loss on Ignition.				Albuminoid.									
		Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	Unfiltered.	Filtered.		
	1899.																	
29331, . .	Nov. 9	813.60	418.20	395.40	348.00	167.60	180.40	1.7700	7.70	3.56	4.14	12.24	-	.0040	82.00	55.20	156.9	6.30-11.45 A.M.
29351, . .	Nov. 9	1225.20	696.80	528.40	548.40	282.00	266.40	9.3700	11.10	4.72	6.38	15.00	-	.0000	133.00	92.50	161.0	1.00-4.45 P.M.
29353,* . .	Nov. 9	340.00	61.60	278.40	88.40	26.80	61.60	1.0200	2.35	0.54	1.81	1.06	.0000	.0002	31.00	10.40	28.3	5.00 P.M.
	1900.																	
31568, . .	June 12	833.20	478.00	355.20	370.00	203.20	166.80	9.3000	7.50	3.50	4.00	12.80	-	.0000	100.00	63.60	-	Tank No. 2.
31621, . .	June 13	510.00	231.20	278.80	226.00	109.20	116.80	4.7000	4.60	2.60	2.00	9.24	-	-	56.80	40.00	-	Tank No. 1.
31680, . .	June 14	418.40	233.20	185.20	178.80	99.60	79.20	3.3000	2.90	1.85	1.05	9.90	.0040	.0000	40.40	31.40	-	Tank No. 1.

Outlet of Tank.

Number.	Date of Collection.	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Unfiltered.	Filtered.	Fats.	
	1899.																	
29332, . .	Nov. 9	499.60	321.00	178.60	234.80	127.60	107.20	2.1200	6.20	2.76	3.44	10.50	-	.0000	60.00	56.00	115.0	7.00-11.45 A.M.
29352, . .	Nov. 9	963.20	678.00	285.20	449.20	265.00	184.20	9.1900	8.60	4.48	4.12	13.00	-	.0000	125.00	91.00	200.8	1.00-4.45 P.M.
29354,* . .	Nov. 9	1066.40	646.60	419.80	465.20	268.20	197.00	10.2900	8.10	4.12	3.98	12.60	-	.0000	121.00	86.00	182.6	5.00 P. M.
	1900.																	
31569, . .	June 12	710.80	444.80	266.00	361.20	196.00	165.20	9.5000	6.20	3.30	2.90	10.40	.0050	.0000	81.60	58.80	-	Tank No. 2.
31622, . .	June 13	448.00	248.00	200.00	206.80	108.00	98.80	6.3000	5.90	2.70	3.20	10.29	-	-	58.80	39.60	-	Tank No. 1.
31681, . .	June 14	379.60	237.20	142.40	172.80	98.00	74.80	3.5000	3.40	2.15	1.25	9.78	.0060	.0000	44.40	32.20	-	Tank No. 1.

* Sample collected while wool-washing machines were being flushed out.

CLINTON.

From the observations and analyses it appears that the average quantity of suspended matter removed from the wastes in passing through the tanks may amount to about 50 per cent. of the total suspended matter in the wool-scouring effluent. The effluent from these settling tanks is discharged into one of the main sewers of the town.

The main sewer which receives the wool-scouring waste is constructed of brick and is laid in the valley of Coachlace Brook. This sewer is 30 inches in diameter. The intercepting sewer, in the valley of the Nashua River, draining the southerly part of the town, is of vitrified pipe 20 and 24 inches in diameter. These sewers are laid below the level of the ground water for long distances, as are also many other sewers in the town, and, since in many of these places no special precautions were taken to prevent the entrance of ground water, the quantity of leakage into the sewers is very large at certain seasons of the year. A few of the sewers are underdrained, the total length of underdrains being about 1,600 feet. Although the system is designed to receive sewage only, a considerable quantity of storm water finds its way into the sewers.

Treatment of the Sewage before Filtration.

At the pumping station the sewage is received in a storage reservoir, circular in section, having a diameter of about 100 feet and designed to contain a depth of 12 feet of sewage. The total capacity of this reservoir is 669,000 gallons. It is designed to hold the night flow of sewage, so that pumping may be done only in the daytime and all of the sewage is pumped from the tank each day.

Provision has been made so that the heavier sewage which accumulates in the bottom of the reservoir may be stirred up by means of perforated pipes laid along the bottom of the reservoir, through which sewage is discharged under pressure from the force main, a provision similar to that at Brockton. In this way no considerable quantity of solid matter accumulates in the reservoir. Before entering the reservoir the sewage passes through screens which consist of inclined iron bars, having open spaces between them of ½ of an inch. The screens are 20 feet wide and 5.9 feet deep, having a total area of 117.5 square feet. The entire area of the screens is available at all times.

The pumping plant consists of a pump having a capacity of 3,000,000 gallons in twenty-four hours. The pump is provided with ordinary water valves, and no serious trouble has been found in keeping them in operation.

In wet weather in the spring much sewage has been allowed to overflow into the river at night, but recently this practice has been discontinued, and all of the sewage is now pumped to the filtration area.

CLINTON.

The force main from the pumping station to the filtration area is constructed of iron pipe 18 inches in diameter and has a total length of 2,287 feet. It is so laid that practically all of the sewage in the pipe at the time the pumps are stopped remains there until pumping is resumed next day, but a small amount flows slowly out at the end of the pipe at the filter beds.

The solid matter which accumulates at the bottom of the reservoir is drawn into the pumps during the last few minutes of pumping, and this heavier sewage remains in the pipe over night and, on this account, the first sewage arriving at the filter beds each morning is much stronger than the average.

The force main contains, when full, about 28,900 gallons of sewage, and, with the average rate of pumping, the velocity through the force main is 2.6 feet per second, and the sewage is fourteen minutes in passing from the pumping station to the filtration area. The difference in elevation between the pumping station and the filter beds is about 50 feet.

Description of the Filter Beds.

The filtration area is located in the town of Lancaster. The total area of land controlled for sewage-disposal purposes is 129.86 acres, but this includes a considerable area of land bordering one of the main highways leading from Clinton to Lancaster which cannot be used for such purposes under the terms of the act. The area was naturally nearly level, at an elevation of about 30 feet above the surrounding lands in the valley of the Nashua River, and the ground water level was several feet beneath the surface. The circumstances were such that a comparatively small amount of grading was necessary in the construction of the filter beds.

There are four dwelling houses within 300 feet of the filter beds, which were taken at the time of the purchase of the area for sewage-disposal purposes, but they are all occupied. There are 12 other houses within half a mile of the filter beds. The nearest of the filter beds is 200 feet from the highway between Clinton and Lancaster already referred to.

Twenty-five filter beds have been prepared having an aggregate area of 23½ acres, most of the beds being about 1 acre in area. In most places the soil and subsoil were removed from the surface of the underlying gravel and sand and used for the construction of embankments between the beds, but in 6 of the beds, having an aggregate area of about 5¾ acres, the subsoil was allowed to remain in place.

The average character of the material of which the filter beds are composed is indicated by a series of samples collected from test pits at the time of the construction of the beds. Only a few of these samples have been analyzed, but it is evident from inspection that the material is very coarse and porous.

Underdrainage.

A careful study was made of the depth of ground water before the beds were constructed by means of tubular wells driven in different parts of the area, and it was found that the ground water came, in places, to within about 5 feet of the surface, while in other portions the ground water level was very much lower than this. In those portions of the area where the ground water was high underdrains were laid 225 feet apart. Further tests, after the sewage was applied to the filters, showed that it was desirable to extend the underdrains to certain other portions of the area than were included in the original plan, and this was accordingly done, so that at the present time 14 beds are underdrained by means of an underdrain passing through the middle of each of the beds, the underdrains discharging through two outlets into a small brook at the northeasterly end of the area which flows through an uninhabited region to the south branch of the Nashua River.

Method of Operating the Filters.

Sewage is applied to the filter beds from pipes laid in the embankments through one outlet upon each bed located at the centre of one side. This outlet is constructed of concrete, with a wall semi-circular in form enclosing a basin, from which the sewage runs out upon the area through holes in the bottom. The sewage remaining in the force-main over night, as already indicated, is much stronger than the average sewage, containing the solid matter which has accumulated in the bottom of the reservoir. This sewage and the sewage pumped from the bottom of the reservoir at the beginning of pumping in the morning is kept separate from the remaining sewage, and has recently been discharged upon beds reserved for this special purpose. During 1903 three beds were used to receive this heavy sewage. The sludge beds, after being used for two or three weeks, contain a heavy deposit of solid matter which ultimately prevents the liquid matter from passing into the sand. When the beds become clogged in this way they are allowed to dry, and the sludge is raked up and removed.

Up to the year 1903 the general method of applying sewage to the filter beds was to allow the entire flow of sewage for a period of from two to three hours to discharge upon a single bed, and by this method doses of from 250,000 to 375,000 gallons per acre per day were applied at one time. In the summer of 1903 the dose was reduced to about 62,500 gallons, the time of application being about thirty minutes. This change was made in order to prevent the overdosing of the filter beds and the consequent poor purification of the sewage.

Records are kept of the quantity of sewage applied to each of the beds and a summary of these records for the years 1900–03 is given in the following table. Each of the beds, with the exception of Nos. 1, 4 and 29, has an area of approximately an acre. No. 1 has an area of 0.25 of an acre, No. 4, 0.50 of an acre and No. 29, 0.75 of an acre.

CLINTON.

Number of Bed.	1900.			1901.		
	Average Quantity of Sewage applied (Gallons per Day).	Number of Doses.	Average Size of Dose (Gallons).	Average Quantity of Sewage applied (Gallons per Day).	Number of Doses.	Average Size of Dose (Gallons).
1,	200	1	88,000	0	0	0
2,	49,000	53	336,000	41,000	51	294,000
4,	14,000	37	142,000	24,000	44	202,000
5,	33,000	43	271,000	41,000	52	293,000
6,	36,000	50	260,000	39,000	54	266,000
8,	33,000	45	264,000	48,000	58	300,000
9,	37,000	49	274,000	33,000	51	239,000
11,	32,000	46	258,000	45,000	54	301,000
12,	38,000	55	252,000	49,000	60	301,000
13,	41,000	52	285,000	41,000	54	278,000
14,	33,000	42	287,000	38,000	50	281,000
15,	35,000	46	281,000	51,000	55	337,000
16,	40,000	53	278,000	43,000	56	281,000
17,	39,000	55	258,000	36,000	56	233,000
18,	44,000	46	348,000	36,000	58	226,000
19,	36,000	45	292,000	41,000	60	250,000
20,	12,000	28	152,000	45,000	49	388,000
22,	37,000	38	358,000	53,000	53	363,000
23,	13,000	33	142,000	35,000	66	194,000
24,	11,000	27	149,000	41,000	49	307,000
25,	35,000	48	269,000	47,000	54	315,000
26,	40,000	40	367,000	41,000	52	289,000
27,	10,000	28	134,000	35,000	66	194,000
28,	11,000	27	135,000	41,000	55	273,000
29,	12,000	31	144,000	39,000	58	246,000
Average,	29,000	41	242,000	39,000	53	264,000

Number of Bed.	1902.			1903.		
	Average Quantity of Sewage applied (Gallons per Day).	Number of Doses.	Average Size of Dose (Gallons).	Average Quantity of Sewage applied (Gallons per Day).	Number of Doses.	Average Size of Dose (Gallons).
1,	400	1	139,000	0	0	0
2,	39,000	49	292,000	48,000	103	169,000
4,	11,000	21	187,000	22,000	60	136,000
5,	44,000	57	285,000	56,000	117	175,000
6,	40,000	56	263,000	61,000	115	194,000
8,	40,000	54	269,000	57,000	112	187,000
9,	23,000	34	250,000	1,200	2	213,000
11,	36,000	50	266,000	46,000	102	165,000
12,	36,000	48	271,000	61,000	116	192,000
13,	36,000	29	271,000	24,000	83	104,000
14,	40,000	39	373,000	67,000	93	264,000
15,	41,000	40	374,000	64,000	110	211,000
16,	36,000	49	266,000	57,000	105	198,000
17,	31,000	43	267,000	24,000	81	109,000
18,	41,000	42	357,000	71,000	101	255,000
19,	40,000	54	270,000	53,000	95	205,000
20,	28,000	43	237,000	46,000	90	186,000
22,	44,000	45	355,000	65,000	95	248,000
23,	29,000	51	208,000	44,000	98	164,000
24,	28,000	47	214,000	51,000	96	184,000
25,	22,000	33	246,000	38,000	109	128,000
26,	47,000	44	394,000	40,000	99	148,000
27,	29,000	51	208,000	44,000	97	164,000
28,	28,000	49	211,000	51,000	101	193,000
29,	29,000	51	211,000	40,000	83	195,000
Average,	33,000	43	267,000	47,000	94	183,000

The average rate of filtration at Clinton during 1903 was about 49,000 gallons per acre per day, but at times of high flow the rate was as great as 71,000 gallons per acre per day, a large quantity when the strength of the sewage is taken into account.

CLINTON.

In winter five of the beds are furrowed and the sewage is applied to the furrowed beds during extremely cold weather. In ordinary weather the unfurrowed beds are able to receive the sewage. In the spring the beds are levelled, and during the summer there is an enormous growth of weeds which requires the frequent scraping or hoeing of the beds. The beds require attention for this reason as often as once in two weeks.

Records of the temperature of the sewage at the pumping station and filtration area were kept for several years and a summary of the records for the year 1901, the last year in which complete records were kept, is given in the following table: —

Average Weekly Temperature of Sewage (Degrees F.).

Week Ending	Screen Chamber.		Reservoir Before Starting Pumps.	West Well.	Filter Beds.	
	7.00 A.M.	At End of Pumping.			At Beginning of Pumping.	Three Hours Later.
Jan. 5,	46.6	49.3	48.3	51.7	48.7	51.0
12,	46.5	49.6	48.1	50.8	47.9	49.9
19,	45.8	50.0	47.5	50.7	47.9	50.3
26,	44.6	49.4	46.9	49.7	46.3	49.1
Feb. 2,	44.4	48.6	45.9	48.9	45.7	48.1
9,	43.2	48.2	45.2	47.9	45.6	46.6
16,	42.2	47.3	43.5	46.9	45.6	46.9
23,	42.8	47.4	43.9	47.2	44.3	45.8
Mar. 2,	42.3	48.9	43.6	46.3	45.3	45.7
9,	42.5	47.4	43.4	46.6	44.4	45.4
16,	42.6	46.7	43.5	46.8	44.6	45.1
23,	43.0	47.1	44.4	46.6	45.6	46.6
30,	43.4	46.7	44.4	46.4	44.4	45.9
April 6,	43.4	46.9	44.0	45.1	44.3	45.3
13,	43.4	45.5	43.9	43.8	44.0	44.3
20,	44.0	45.8	44.9	45.3	45.4	45.8
27,	44.6	46.6	45.2	45.4	45.1	46.4
May 4,	45.4	48.6	45.9	46.8	46.0	47.6
11,	47.3	51.8	49.0	50.6	48.9	49.7
18,	48.9	54.6	51.4	52.5	50.9	51.4
25,	49.8	54.1	52.1	53.0	52.3	52.9
June 1,	50.1	52.1	51.5	52.9	51.4	31.9
8,	52.1	57.6	53.7	54.7	54.3	54.4
15,	54.4	58.9	58.0	59.1	56.6	57.4
22,	56.3	62.9	59.6	60.6	59.9	61.3
29,	58.4	65.6	62.6	63.1	62.0	63.6
July 6,	62.4	65.4	66.2	66.6	66.1	66.8
13,	62.9	69.1	65.3	68.0	66.4	68.1
20,	64.6	70.0	67.4	68.7	67.7	69.4
27,	65.4	70.4	68.1	69.3	68.3	69.7
Aug. 3,	64.3	69.6	66.9	67.9	67.6	69.9
10,	64.4	69.8	67.1	68.3	67.4	69.1
17,	64.5	70.6	67.3	68.2	68.4	69.7
24,	65.4	71.4	68.1	69.0	68.9	69.6
31,	65.6	69.9	67.9	68.9	68.9	70.1
Sept. 7,	64.8	69.8	66.9	67.9	68.9	70.0
14,	63.7	69.1	65.1	68.2	68.6	69.3
21,	62.9	66.7	66.3	66.9	65.4	67.3
28,	60.6	62.4	62.9	64.1	64.3	65.3
Oct. 5,	59.9	63.1	61.7	62.7	61.7	61.6
12,	59.1	61.1	60.4	62.1	60.7	60.9
19,	58.1	61.1	59.4	60.7	59.3	59.4
26,	57.3	60.9	58.5	59.5	58.7	59.0
Nov. 2,	56.1	60.1	57.2	59.1	57.7	57.0
9,	54.9	58.5	56.4	58.4	56.9	58.0
16,	54.2	57.1	35.4	56.2	53.9	54.9
23,	51.3	54.1	52.2	54.5	51.1	52.3
30,	49.6	52.1	50.7	53.1	50.4	51.0
Dec. 7,	48.8	51.6	49.6	52.4	49.6	50.7
14,	48.3	51.9	48.9	50.9	48.9	50.3
21,	47.4	48.3	47.7	47.4	46.4	46.9
28,	46.3	48.7	47.0	48.1	47.0	47.4

CLINTON.

Character of the Sewage.

The sewage of Clinton is very strong. Its average character is shown by the yearly averages of chemical analyses given in the following table: —

Yearly Averages of Chemical Examinations of Sewage from Clinton.

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Oxygen Consumed.	
	Total Residue.			Loss on Ignition.			Free.	Albuminoid.					
	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.		Total.	Dissolved.	Suspended.		Unfiltered.	Filtered.
1900, . .	116.32	80.46	35.86	55.05	32.48	22.57	3.86	1.35	.79	.56	7.06	14.45	10.98
1901, . .	87.48	70.15	17.33	42.78	31.93	10.85	3.45	1.00	.56	.44	5.41	10.72	8.56
1902, . .	101.58	74.90	26.68	51.78	34.00	17.78	4.12	1.05	.65	.40	6.17	11.75	8.30
1903, . .	94.94	72.75	22.19	47.84	32.34	15.50	4.04	0.96	.68	.28	5.95	11.37	8.76

Character of the Effluent.

The effluent from the Clinton filtration area has frequently a strong odor and has contained recently an excessive quantity of iron, indicating incomplete purification. The character of the effluent from the two principal underdrains is shown in the following tables: —

Yearly Averages of Chemical Examinations of the Effluent from the East Underdrain.

[Parts per 100,000.]

Year.	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
1900, ...	.60	38.85	1.0191	.0916	4.89	.7833	.0160	1.17	6.2	.2708
1901, ...	.84	37.09	.7392	.0955	4.82	.8783	.0106	1.10	5.5	.2624
1902, ...	.66	37.13	.8067	.0995	4.75	.8586	.0594	1.28	5.6	.6204
1903, ...	-	44.60	1.4852	.1040	5.38	.1753	.0291	1.40	6.4	1.8920

Yearly Averages of Chemical Examinations of the Effluent from the West Underdrain.

1900, ...	.34	35.71	1.0904	.0903	4.75	.7196	.0188	1.09	6.5	.1749
1901, ...	.16	31.77	.4192	.0526	4.51	.9812	.0297	.54	4.9	.0725
1902, ...	.51	36.42	.5655	.0785	4.75	1.1804	.0191	1.01	5.3	.1679
1903, ...	-	38.72	.5494	.0509	5.72	.7045	.0108	.84	6.5	.5064

Purification effected by the Clinton Sewage Filters.

From the results of the yearly averages of analyses of sewage and effluent given in the preceding tables the percentages of organic matters removed in the process of filtration, as shown by the free ammonia, albuminoid ammonia and oxygen consumed, have been calculated and are presented in the following table. Tables are also appended showing, in a similar way, the purification effected in the six warmer months of the year, from June to November, inclusive, and in the six colder months, from December to May, inclusive. The underdrains of the Clinton filtration area receive, in addition to the sewage effluent, a considerable quantity of ground water, and, in order to indicate the actual amount of purification, calculated analyses have been made, making allowance for the dilution by ground water, and the results, as shown by such analyses, are also presented.

Purification effected by the Sewage Filters at Clinton.

East Underdrain.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent Removed	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1900,	3.86	1.0191	73.6	1.35	.0916	93.2	14.45	1.17	91.9
1901,	3.45	0.7392	78.6	1.00	.0955	90.4	10.72	1.10	89.7
1902,	4.12	0.8067	80.4	1.05	.0995	90.5	11.75	1.28	89.1
1903,	4.04	1.4852	63.3	0.96	.1040	89.2	11.37	1.40	87.7

West Underdrain.

1900,	3.86	1.0904	71.8	1.35	.0903	93.3	14.45	1.09	92.5
1901,	3.45	0.4192	87.8	1.00	.0526	94.7	10.72	0.54	95.0
1902,	4.12	0.5655	86.3	1.05	.0785	92.5	11.75	1.01	91.4
1903,	4.04	0.5494	86.4	0.96	.0509	94.7	11.37	0.84	92.6

Purification effected by the Sewage Filters at Clinton during the Summer Months (from June to November, inclusive) of Each Year.

East Underdrain.

1900,	4.84	0.5350	88.9	1.66	.0849	94.9	17.54	0.93	94.6
1901,	3.84	0.3683	90.4	1.04	.0577	94.5	10.67	0.79	92.6
1902,	5.19	0.8467	83.7	1.03	.1187	88.5	10.92	1.51	86.2
1903,	4.73	1.5867	66.5	1.06	.0950	91.0	12.85	1.35	89.5

West Underdrain.

1900,	4.84	.6912	85.7	1.66	.0720	95.7	17.54	.98	94.4
1901,	3.84	.1947	94.9	1.04	.0359	96.5	10.67	.42	96.1
1902,	5.19	.4250	91.8	1.03	.0706	93.1	10.92	.79	92.8
1903,	4.73	.5840	87.6	1.06	.0412	96.1	12.85	.69	94.6

CLINTON.

Purification effected by the Sewage Filters at Clinton during the Winter Months (from December to May, inclusive) of Each Year.

East Underdrain.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent Removed.
1900, ...	3.09	1.6340	47.1	1.16	.1091	90.6	12.95	1.51	88.4
1901, ...	2.98	1.1217	62.4	0.92	.1283	86.1	10.05	1.34	86.7
1902, ...	2.93	0.5833	80.1	1.03	.0711	93.1	11.93	0.91	92.4
1903, ...	2.77	1.2780	53.9	0.79	.1085	86.3	9.52	1.47	84.6
West Underdrain.									
1900, ...	3.09	1.6336	47.1	1.16	.1080	90.7	12.95	1.23	90.5
1901, ...	2.98	0.6720	77.4	0.92	.0779	91.5	10.05	0.78	92.2
1902, ...	2.93	0.6793	76.8	1.03	.0762	92.6	11.93	1.03	91.4
1903, ...	2.77	0.4575	83.5	0.79	.0806	89.8	9.52	1.27	86.7

Purification effected by the Sewage Filters at Clinton as indicated by the Calculated Analyses of the Effluent.

East Underdrain.

1900, ...	3.86	1.4891	61.4	1.35	.1343	90.1	14.45	1.71	88.2
1901, ...	3.45	0.8324	75.9	1.00	.1060	89.2	10.72	1.24	88.4
1902, ...	4.12	1.0573	74.3	1.05	.1304	87.6	11.75	1.68	85.7
1903, ...	4.04	1.6466	59.2	0.96	.1153	88.0	11.37	1.55	86.4
West Underdrain.									
1900, ...	3.86	1.6397	57.5	1.35	.1358	90.0	14.45	1.64	88.7
1901, ...	3.45	0.5066	85.3	1.00	.0639	93.6	10.72	0.65	93.9
1902, ...	4.12	0.7412	82.0	1.05	.1029	90.2	11.75	1.32	88.8
1903, ...	4.04	0.5723	85.8	0.96	.0530	94.5	11.37	0.88	92.3

Cost of the Works.

The cost of constructing the purification works is shown in the following table: —

Reservoir and force main, ...	$34,016 06
Pumping station, ...	5,499 54
Pumping plant, ...	6,200 00
Land for filter beds and pumping station (135.18 acres), .	37,794 40
Filter beds (23½ acres), ...	21,162 62
Total, ...	$104,672 62

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Cost of Maintenance of the Filters.

The cost of maintenance, as given in the reports of the Metropolitan water and sewerage board, has been as follows: —

Year.	Pumping Station.	Filter Beds.	Total.
1900,	$2,248 54	$2,029 09	$4,277 63
1901,	2,520 49	2,534 85	5,055 34
1902,	2,390 99	2,344 44	4,735 43
1903,	2,678 35	2,235 04	4,913 39

Concord.

Population in 1900, 5,652.

The town is situated on the Concord River at the junction of its two principal tributaries, the Assabet and Sudbury rivers. The population is located chiefly in two villages, — the main village of Concord, which contains the principal part of the population and is situated at the junction of the Assabet and Sudbury rivers, and the village of Westvale on the Assabet River, including the Massachusetts Reformatory, which has a population, including officers and employees, of about 1,200.

A public water supply was introduced into the town from Sandy Pond in 1873 which is furnished to both of the main villages, and at the end of the year 1903 there were 31.5 miles of water pipe and 919 service pipes in use in the town. The water is supplied by gravity and no record is kept of the quantity used.

Sewerage System.

The sewerage system was constructed in 1898 and 1899 and is available to the inhabitants of the main village only. The sewage of the Concord Reformatory is disposed of upon the grounds of that institution. The sewage of the main village of Concord is collected in a system of pipe sewers through which it is conveyed to a reservoir and pumping station near the Concord River, whence it is pumped to a filtration area about one mile north-east of the main village and adjacent to the Concord Branch of the Boston & Maine Railroad, where it is purified by intermittent filtration. Two of the tributary sewers leading to the main sewer in the valley of the Concord River pass beneath the bottom of the river, being laid in the form of inverted siphons and built of iron pipe. A flush tank is located at the upper end of each of these siphons, so arranged as to discharge automatically as it becomes filled with sewage. One tank, discharging through a siphon 8 inches in diameter, has a capacity of 1,570 gallons, while the other, discharging also through a pipe 8 inches in diameter, has a capacity of 7,400 gallons. The siphons are so arranged that their contents may be pumped out at man-holes at their lower ends, but no trouble has

CONCORD.

thus far been experienced in the operation of these siphons and it has not been necessary to clean them out.

The total length of sewers constructed up to the end of 1903 was 7.53 miles, and 238 buildings had then been connected with the system, classified as follows: —

Dwellings,	211
Business blocks,	15
Public buildings,	4
Hotels,	2
Churches,	2
Schools,	3
Railroad station,	1
Total,	238

The estimated population using the sewers is 1,200.

At the pumping station the sewage discharges into a subterranean storage reservoir having a capacity of 373,000 gallons when full.

The reservoir is circular in shape, 57 feet in diameter and holds a maximum depth of sewage of about 20 feet. There is a screen chamber at the entrance to this reservoir containing a screen 5.5 feet wide and 5 feet high, having an area of 27.5 square feet constructed of wooden slats with an open space between them of half an inch. At times of heavy flow the screen is cleaned about once in two weeks, and about two wheel-barrow loads of material are removed each time. At other times it is cleaned less frequently.

There is no provision for the removal of solid matter from the reservoir excepting through the pumps, and practically all of the matter entering the reservoir is removed in that way. The bottom of the reservoir is cleaned occasionally, the principal material found being sand, which finds its way into the sewers chiefly through the man-hole covers.

The pumping station is used also as the station for the electric lighting plant of the town. Sewage is forced to the filtration area by means of a pump having a capacity of about 1,000,000 gallons in twenty-four hours, the pumping of sewage being done at times when the work of the electric lighting plant is lightest. The pumps are provided with ordinary water valves, and considerable difficulty has been experienced in keeping them clean. The sand contained in the sewage, moreover, is troublesome on account of wearing the cylinders of the pumps.

The force main from the pumping station to the filtration area is of cast iron, 10 inches in diameter and about 5,000 feet in length, the total elevation through which the sewage is raised being about 50 feet. The force main is provided with blow-offs through which the contents of the pipe can

be discharged, but the pipe ordinarily remains full when the pumps are not in operation, and contains at such times 20,000 gallons of sewage. When the pumps are operated at the normal rate the sewage in the force main has a velocity of 2.86 feet per second, and passes from the reservoir to the filtration area in about thirty minutes.

Quantity of Sewage.

There are no factories connected with the sewers from which manufacturing wastes in any considerable quantity are discharged into the system, so that the sewage of this system is strictly domestic sewage.

Care was taken in the construction of the sewers to prevent the entrance of ground water, as the soil in which they were laid consisted largely of sand, and more than half of the sewers were laid below the level of the ground water. In the course of the construction of the sewers underdrains were laid in many places, but their outlets were closed when the sewers were completed. Notwithstanding the efforts to prevent leakage into the system, observations upon the quantity of water flowing in the sewers before any connections were made showed a flow of 200,000 gallons per day, or 30,000 gallons per mile of sewer. These measurements were not made at the time of maximum leakage.

The quantity of sewage pumped during the past three years, deduced from the pumping records, is shown in the following table: —

Quantity of Sewage pumped, in Thousand Gallons per Day.

Month.	1901.			1902.			1903.		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
January,	207	320	135	374	501	219	351	399	295
February,	184	310	146	341	570	287	363	467	300
March,	213	285	148	487	651	300	433	533	327
April,	398	600	184	490	733	306	455	742	328
May,	454	560	400	398	600	312	357	417	293
June,	407	549	240	250	564	176	359	580	209
July,	264	335	219	191	244	154	321	426	214
August,	232	278	155	191	225	162	246	354	133
September,	215	313	166	225	280	164	230	301	158
October,	226	289	186	254	351	226	201	287	136
November,	185	241	136	250	279	217	203	254	184
December,	289	503	184	297	456	180	225	295	151
Year,	273	600	135	312	733	154	312	742	133

It will be seen from the above figures that the maximum flow of sewage in the months of March, April, May, and sometimes in June, is several times the flow of sewage recorded in the drier months of the year, showing that a great quantity of water leaks into the sewers at such times.

CONCORD.

The following table gives the statistics of the average, maximum and minimum daily flow of sewage in 1903 with relation to the number of inhabitants, sewer connections, etc.: —

	Gallons per Day.		
	Average.	Maximum.	Minimum.
Total flow,	312,000	742,000	133,000
Flow per inhabitant,	53	125	22
Flow per person connected,	260	618	111
Flow per connection,	1,311	3,118	559
Flow per mile of sewer,	41,430	98,540	17,660

On account of the great leakage into the sewers, the sewage of the town of Concord is very weak.

Treatment of the Sewage before Filtration.

The sewage before entering the reservoir, as already stated, is screened, and about one wheel-barrow load of material is removed from the screens each week at times of maximum flow. In the reservoir the heavier organic matters settle to the bottom and tend to collect there, but care is exercised to pump the reservoir completely out at each pumping, and practically no matter is removed from the sewage in passing through the reservoir. All the sewage is pumped upon the filtration area and, while some of the heavier sewage doubtless remains in the force main over night, no attempt is made to treat this portion separately from the remaining sewage.

Description of the Filter Beds.

The filtration area comprises a tract of land having an area of 14.1 acres adjacent to the Concord Branch of the Boston & Maine Railroad, as already described. There are no highways near the filtration area, and the nearest house is about 3,000 feet distant. There are about fifteen houses within three-quarters of a mile of the area. The area is quite regular in contour and consists of fine and coarse sand, the material becoming coarser as the depth increases. The level of the ground water is ordinarily many feet below the surface. Upon this tract of land four filter beds have been constructed having an aggregate area of 3.3 acres, the largest having an area of about an acre and the smallest half an acre. All of the soil and subsoil was removed from the area and used in the construction of embankments between the beds, and the sewage is applied directly to the sandy soil thus exposed. The character of this soil is shown by samples collected from various depths at the middle of each of the beds, the results of which are given in the following table.

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Analyses of Filtering Material of the Concord Filter Beds.

Depth Beneath Surface (Feet).	Effective Size (Millimeters).			Uniformity Coefficient.			Albuminoid Ammonia (Parts per 100,000).		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
Surface,	.10	.11	.07	2.9	3.7	2.3	56.05	74.45	42.55
0.25,	.09	.10	.07	2.8	3.6	2.5	22.77	29.55	12.97
0.50,	.08	.10	.07	3.0	3.8	2.3	15.93	20.53	9.68
1.00,	.08	.10	.07	3.2	5.4	1.9	8.98	10.31	7.34
2.50,	.24	.54	.07	3.1	3.8	2.8	5.35	7.00	2.01

Underdrainage.

No underdrains have been laid in connection with this filtration area, and no disturbance of the soil has taken place beyond that necessary for the removal of the surface loam and subsoil. The area is naturally underdrained by very coarse sand. The railroad passes along the edge of the area in a deep cut, and a small quantity of the sewage effluent flows out upon the ground in a depression from which material was removed in the construction of the railroad. The effluent appears also in the form of springs in a small valley near the area, and samples have been obtained from these places.

The sewage is discharged upon the beds at the four corners of each bed from pipes laid in the embankments between the beds, and the rate of pumping is such that practically the entire surface of a filter bed can be flooded with an ordinary dose of sewage without much difficulty.

Method of Operating the Filters.

During the summer time the entire flow of sewage is ordinarily discharged upon one bed for two days and then diverted to another bed, which in turn receives two days' flow, and in this way all of the beds are used in rotation. In winter the sewage is sometimes applied to one bed continuously for periods of a week or ten days, using the beds in rotation as in the summer.

The beds are prepared for winter by furrowing, and in the spring are levelled and harrowed. During the summer they are cleaned about once in two weeks, the principal cleaning required being the removal of weeds from the surfaces. No crops are raised upon the area and very little organic matter requiring removal has yet collected upon the surfaces of the beds.

No difficulty has been experienced in operating the beds in the coldest weather, though the conditions here are similar to those at Andover, with possibly lower minimum temperatures.

Character of the Sewage.

The Concord sewage is an extremely weak domestic sewage, owing to the absence of manufacturing wastes and the great quantity of leakage

CONCORD.

The following table gives the statistics of t
minimum daily flow of sewage in 1903 with rel:
habitants, sewer connections, etc.: —

	A\
Total flow,	
Flow per inhabitant,	
Flow per person connected,	
Flow per connection,	
Flow per mile of sewer,	

On account of the great leakage into
of Concord is very weak.

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Treatment of the Sew

The sewage before entering the res
and about one wheel-barrow load of
each week at times of maximum flow
matters settle to the bottom and te
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to treat this portion separately f

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rom the Concord Sewage

The filtration area compris
adjacent to the Concord Bran
described. There are no hig
house is about 3,000 feet
three-quarters of a mile of
and consists of fine and c
depth increases. The le
below the surface. Upo
structed having an aggr
of about an acre and th
was removed from the
between the beds, an

		Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	2.63	.4145	.0014	.24	4.8	.0087
	2.65	.9512	.0000	.11	5.2	.0070
.904	2.59	.8467	.0000	.11	5.1	.0041

d by the Concord Sewage Filters.

exposed. The chara early averages of analyses of sewage and effluent
various depths at th table the percentages of organic matters removed
given in the followi filtration, as represented by the free ammonia, albuminoid
n consumed, have been ca d and are presented in

CONCORD.

'ˀ. Tables are also presented showing the purification
ʳmer months of the year, from June to November,
ˀolder months, from December to May, inclusive.

'd by the Sewage Filters at Concord.

[Parts per 100,000.]

	...MONIA.			TOTAL ALBUMINOID AMMONIA.			OXYGEN CONSUMED.		
		Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
	.3	.0032	99.5	.30	.0177	94.1	1.44	.24	83.3
	.91	.0016	99.8	.22	.0093	95.8	1.61	.11	93.2
	0.69	.0017	99.8	.17	.0104	93.9	1.36	.11	91.9

l by the Sewage Filters at Concord during the Summer Months (from June to November, inclusive) of Each Year.

.	0.70	.0047	99.3	.25	.0209	91.6	1.57	.34	78.3
. .	1.17	.0021	99.8	.22	.0100	95.5	1.50	.09	94.0
. .	0.70	.0017	99.8	.16	.0122	92.4	1.55	.10	93.5

...on effected by the Sewage Filters at Concord during the Winter Months (from December to May, inclusive) of Each Year.

. . . .	0.54	.0014	99.7	.41	.0149	96.4	1.47	.14	90.5
. . . . .	0.61	.0010	99.8	.17	.0094	94.5	1.43	.13	90.9
. . . . . .	0.68	.0018	99.7	.23	.0079	96.6	1.38	.11	92.0

The effluent of the Concord filters has been very thoroughly purified at all times and is not distinguishable in appearance or odor from ordinary spring water. It finds its way into the small streams near the filters and thence into the Concord River.

Cost of the Works.

The cost of constructing the purification works, obtained from the printed reports of the sewer department, is given in the following table: —

Land for filter beds (14.1 acres),	$1,000 00
Construction of 4 filter beds,	2,600 00
Force main,	4,893 27
Storage well,	17,098 46
Land for pumping and power station,	750 00
Pumping and power station,	20,740 50
Pumping machinery,	1,762 73
Total,	$48,844 96

CONCORD.

Cost of Maintenance.

The purification works are operated by one man who ordinarily devotes only a part of his time to the work. The annual cost of maintenance for the past three years has been as follows: —

1901,	$285 47
1902,	428 50
1903,	327 10

The area available for the purification of the sewage of Concord is ample for present requirements and can readily be enlarged when necessary. All of the sewage collected in the sewers is discharged upon the area and efficiently purified before being allowed to flow into neighboring streams. There has been no complaint of odor or other objectionable conditions arising from the use of these lands for sewage-disposal purposes.

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Population in 1900, 11,302.

The town of Framingham is situated within the water-shed of the Sudbury River. The population is located principally in three villages, — South Framingham, Framingham Center, about two miles north-west of South Framingham, and Saxonville, in the north-easterly part of the town 3½ miles from South Framingham.

A public water supply was introduced in 1885 from a filter gallery on the shore of Farm Pond near the village of South Framingham. The water is supplied to the village of South Framingham and a portion of the village of Framingham Center, but the works have not been extended to Saxonville. At the end of 1903 there were 23.9 miles of water pipe in use and 1,293 services connected therewith. The average daily consumption of water in the year 1903 was 524,000 gallons.

The village of South Framingham is situated in part within the water-shed of the Sudbury River above the point at which the water is diverted for the water supply of the Metropolitan district of Boston and in part within the water-shed of Lake Cochituate, also used as a source of supply for the Metropolitan district. The village of Framingham Center is situated chiefly in the portion of the water-shed of the Sudbury River below the place where that stream is used as a source of water supply, and the village of Saxonville is situated still farther down the stream.

Sewerage System.

The sewerage system was constructed in 1889 and is available only to the inhabitants of the village of South Framingham, but the sewage of the Reformatory Prison for Women, situated within the limits of the town of Sherborn near South Framingham, is also disposed of through the Framing-

ham system. The sewage is collected in a system of pipe sewers constructed upon the separate plan and conveyed to a reservoir and pumping station in the valley of Beaver Dam Brook, a tributary of Lake Cochituate, whence it is pumped to a filtration area in the north-westerly portion of the town of Natick, where it is purified by intermittent filtration.

The total length of sewers constructed up to the end of the year 1903 was about 15.75 miles, and 1,214 buildings were connected with the system at that time. These buildings may be classified as follows: —

Dwelling houses,	1,165
Business blocks,	27
Factories,	9
Schoolhouses,	6
Hotels,	3
Churches,	4
Total,	1,214

The estimated population contributing sewage at the end of 1903 was 7,500, including a population of about 350 in the Reformatory Prison for Women in Sherborn.

The sewers are for the most part constructed of tile pipes, but the main sewer is of brick; and a tributary sewer, laid in the valley of Beaver Dam Brook, consists of iron pipe with lead joints for a distance of 1.75 miles, where the sewer was laid in very wet soil.

Quantity of Sewage.

The quantity of sewage pumped to the filtration area during each of the last 6 years, as shown by the pumping records, is given in the following table: —

Quantity of Sewage pumped, in Thousand Gallons per Day.

Month.	1898.			1899.			1900.		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
January,	467	515	431	568	671	499	495	776	422
February,	648	1,020	510	552	651	489	639	739	569
March,	698	915	510	820	989	711	758	921	521
April,	525	610	510	664	862	378	694	858	612
May,	510	561	481	468	591	410	651	750	532
June,	451	486	410	455	495	364	608	712	425
July,	390	399	360	408	502	340	361	463	298
August,	398	421	360	352	428	284	328	411	300
September,	386	399	378	354	420	322	332	412	303
October,	378	416	340	409	450	248	417	594	215
November,	499	611	416	430	475	319	477	781	344
December,	607	789	516	444	490	399	739	1,038	600
Year,	495	1,020	340	493	989	248	541	1,038	215

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Quantity of Sewage pumped, in Thousand Gallons per Day — Concluded.

Month.	1901. Average.	1901. Maximum.	1901. Minimum.	1902. Average.	1902. Maximum.	1902. Minimum.	1903. Average.	1903. Maximum.	1903. Minimum.
January,	621	784	464	734	970	551	761	986	431
February,	492	582	405	590	737	444	640	826	508
March,	661	978	416	955	1,737	576	890	1,840	610
April,	1,049	1,305	698	801	936	632	967	1,098	803
May,	907	1,116	755	600	735	504	763	979	610
June,	793	898	672	498	592	385	662	986	427
July,	542	741	389	446	559	304	503	780	412
August,	469	769	396	448	518	331	502	774	402
September,	515	823	398	432	496	381	476	682	412
October,	495	682	398	445	535	382	531	696	428
November,	459	534	373	448	498	410	581	672	502
December,	696	994	418	544	928	417	545	598	497
Year,	642	1,305	373	579	1,737	304	652	1,840	402

The following table gives the average, maximum and minimum flow per inhabitant, per person connected with the sewers, etc., during the year 1903: —

	Flow of Sewage (Gallons per Day). Average.	Maximum.	Minimum.
Total flow,	652,000	1,840,000	402,000
Flow per inhabitant,	53	149	32
Flow per person connected with the sewers,	87	245	54
Flow per connection,	537	1,514	331
Flow per mile of sewer,	41,400	116,800	25,500

Considerable care was taken when the first sewers were constructed to prevent leakage into them, and underdrains were laid beneath about three miles of main sewers, the water from which was originally discharged into Beaver Dam Brook, a tributary of Lake Cochituate, but is now pumped to a filter bed near the brook. In subsequent extensions of the sewers, underdrains have not been built, and there is considerable leakage into these portions of the system.

One of the principal contributors of sewage to this system is the Massachusetts Reformatory Prison for Women in Sherborn, which has an independent water supply. A measurement of the flow of sewage in 1898 indicated that this institution was then discharging about 35,000 gallons per day into the Framingham system.

The Dennison Manufacturing Company, employing about 1,400 persons, contributes, in addition to all of the sewage from the factory, considerable quantities of manufacturing wastes, consisting of dye liquors. The calculated quantity of water used in this factory, which has an independent

source, at the present time is about 40,000 gallons per day, much of which doubtless enters the sewers.

A hat factory employing about 400 persons during six months in the year discharges wastes from dyeing and bleaching into the sewers. The amount of water used in this factory is about 18,000 gallons per day when in operation.

In consequence of the manufacturing wastes discharged into the sewers the sewage is often greatly discolored by dye liquors.

Treatment of the Sewage before Filtration.

The sewage, before entering the reservoir at the pumping station, passes through screens, consisting of wooden slats with an open space between of $\frac{3}{4}$ of an inch. The aggregate area of the screens is 60 square feet. These screens are cleaned twice a week, and about a wheel-barrow load of solid matter is removed, which is burned beneath the boilers. The covered masonry reservoirs into which the sewage is received are two in number, each 110.5 feet long and 30 feet wide, with a maximum depth of sewage of 11.75 feet. Their capacity is 431,000 gallons, which is sufficient for the storage of the night flow of sewage, so that the pumps are operated only during the daytime.

No arrangement has been made for flushing out any solid matter that may be deposited in the bottom of the reservoir, except that the bottom has a slight slope toward the pump well. Very little solid matter collects in the bottom of the reservoirs, which are cleaned out about once each year by stirring up the sediment when the reservoir is nearly empty and pumping it out with the sewage.

The pumping plant consists of two pumps, each having a capacity of about 1,000,000 gallons per day. The pumps are provided with specially designed flap valves, each of which has an area of about 43 square inches. All of the sewage received at the pumping station has been pumped to the filtration area, and no sewage has been allowed to flow into the stream near which the pumping station is located.

The force main from the pumping station to the filtration area consists of a cast iron pipe 12 inches in diameter and 9,700 feet in length, the lift from the reservoir to the filter beds being 44 feet. The force main is so laid that when the pumps are stopped all but a short portion near the filter beds remains full of sewage, the quantity so held being about 57,000 gallons. When the pumps are operated at their normal rate the velocity through the force main is about 3.9 feet per second.

The sewage remaining in the force main consists of the heavier sewage pumped from the bottom of the reservoir on the preceding day and contains much solid matter, but no attempt is made to keep this sewage separate, and all of the sewage is applied directly to the filter beds.

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Description of the Filter Beds.

The area controlled by the town for sewage-disposal purposes comprises about 100 acres originally covered with wood, much of it being a nearly level plain composed of coarse gravel situated at a considerable elevation above Bannister Brook, toward which it naturally drains. There is no population in the immediate neighborhood of the filtration area, the nearest house being about 500 feet distant, and there are not more than six houses within half a mile. The area is situated on the northerly side of the Boston and Worcester turnpike, which also contains the location of the Boston & Worcester Electric Railroad. Upon this tract 18 filter beds have been constructed having an aggregate area of 19.9 acres. The filter beds were prepared by removing the trees and stumps. None of the sub-soil was removed from the beds except so far as was necessary in levelling them and in constructing the embankments. The surface of one of the beds received no further preparation than the removal of the trees, the stumps being left in place.

The average character of the material of which the filter beds are composed, as determined from samples of the soil collected at the middle of each of the filter beds after they had been in use about nine years, is shown in the following table: —

Analyses of Filtering Material of the Framingham Filter Beds.

Depth Beneath Surface (Feet).	Effective Size (Millimeters).			Uniformity Coefficient.			Albuminoid Ammonia (Parts per 100,000).		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
Surface,	.06	.32	.03	13.9	26.3	5.9	64.4	119.1	33.4
0.25,	.06	.37	.03	12.8	26.9	6.3	54.2	89.1	24.8
0.50.	.07	.39	.03	13.1	25.7	5.4	45.2	80.4	21.1
1.00,	.12	.36	.03	10.7	23.4	2.9	24.4	86.2	7.0
2.50,	.11	.21	.08	8.0	22.4	2.0	10.0	20.7	2.2

The results of this examination show that the material is very fine near the surface and contains a considerable quantity of organic matter, probably due partly to the fact that the subsoil was not removed when the beds were first constructed.

Underdrainage.

A line of underdrains passes through the middle of eleven of the beds about 6 feet beneath the surface, the underdrains discharging into open ditches leading to Bannister Brook. The remaining seven beds are not underdrained, and a comparatively small portion of the sewage effluent is collected by the underdrains, much of the effluent passing to the brook through the coarse material which underlies the filtration area. There are several springs along Bannister Brook evidently supplied largely by sewage

effluent. The water of one of these springs has been examined regularly since the works were first used, and serves to indicate the character of the effluent which reaches the brook after passing a long distance through the ground.

Method of Operating the Filters.

Sewage is applied to the filter beds from man-holes at two corners of each of the beds. In some cases the sewage is discharged from the man-holes into channels passing along the foot of the inside slope of the embankment between the beds, and is delivered from this channel to the beds through openings at various points.

The rate at which sewage is delivered at the filtration area by the pumps is such that the beds can be quickly flooded, but the surfaces of some of the beds are not level and sewage does not reach all portions of the beds, especially those to which the sewage is delivered at only two points. During the summer season the whole flow of sewage is ordinarily applied to one bed each day, while in the winter and spring, when the flow is greater, two or three of the beds are used to receive the day's sewage. In this way the dose which the beds receive is very large, and there is a long period of rest between the doses.

Records have been kept of the distribution of the sewage on the filter beds since the beginning of the year 1898, and from these records the following table has been prepared giving the approximate quantity of sewage applied to each of the beds and the number and average size of the doses during each year.

Quantity of Sewage applied to Framingham Filter Beds.

Number of Bed.	Size of Bed (Acres).	1898. Average Quantity of Sewage applied.				1899. Average Quantity of Sewage applied.			
		Gallons per Day.	Gallons per Day per Acre.	Number of Doses.	Average Size of Dose (Gallons).	Gallons per Day.	Gallons per Day per Acre.	Number of Doses.	Average Size of Dose (Gallons).
1, ...	1.16	17,000	15,000	23	266,000	26,000	22,000	40	235,000
2, ...	1.30	16,000	12,000	24	245,000	31,000	24,000	43	257,000
3, ...	1.30	29,000	22,000	31	338,000	22,000	17,000	29	276,000
4, ...	1.30	39,000	30,000	40	364,000	36,000	28,000	36	361,000
5, ...	1.30	26,000	20,000	30	336,000	43,000	33,000	46	292,000
6, ...	1.13	43,000	38,000	44	327,000	38,000	34,000	43	324,000
7, ...	1.63	38,000	23,000	35	400,000	73,000	45,000	65	351,000
8, ...	1.15	58,000	50,000	59	359,000	37,000	32,000	47	282,000
9, ...	1.15	53,000	46,000	52	369,000	29,000	25,000	35	302,000
10, ...	1.15	30,000	26,000	26	425,000	49,000	43,000	47	384,000
11, ...	1.04	25,000	24,000	38	225,000	26,000	25,000	38	246,000
12, ...	1.01	28,000	28,000	42	225,000	23,000	23,000	35	241,000
13, ...	0.44	10,000	23,000	16	228,000	11,000	25,000	20	203,000
14, ...	0.70	12,000	17,000	19	222,000	25,000	36,000	27	246,000
15, ...	0.55	13,000	24,000	18	229,000	10,000	18,000	14	251,000
16, ...	0.64	11,000	17,000	15	229,000	5,000	8,000	9	204,000
17, ...	1.43	28,000	20,000	23	451,000	15,000	10,000	15	367,000
Stump bed, .	1.52	24,000	16,000	17	505,000	19,000	13,000	20	200,000
Average, .	1.11	28,000	25,000	31	369,000	29,000	25,000	34	279,000

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Quantity of Sewage applied to Framingham Filter Beds — Continued.

Number of Bed.	Size of Bed (Acres).	1900. Average Quantity of Sewage applied. Gallons per Day.	1900. Average Quantity of Sewage applied. Gallons per Day per Acre.	1900. Number of Doses.	1900. Average Size of Dose (Gallons).	1901. Average Quantity of Sewage applied. Gallons per Day.	1901. Average Quantity of Sewage applied. Gallons per Day per Acre.	1901. Number of Doses.	1901. Average Size of Dose (Gallons).
1, ...	1.16	22,000	19,000	30	266,000	29,000	25,000	28	377,000
2, ...	1.30	24,000	18,000	31	285,000	27,000	21,000	28	347,000
3, ...	1.30	41,000	31,000	47	316,000	19,000	15,000	21	347,000
4, ...	1.30	48,000	37,000	49	355,000	42,000	32,000	40	384,000
5, ...	1.30	35,000	27,000	47	270,000	43,000	33,000	39	406,000
6, ...	1.13	32,000	29,000	41	290,000	41,000	36,000	35	427,000
7, ...	1.63	55,000	34,000	61	327,000	54,000	33,000	50	396,000
8, ...	1.15	31,000	27,000	42	271,000	73,000	63,000	69	387,000
9, ...	1.15	30,000	26,000	39	278,000	41,000	36,000	45	332,000
10, ...	1.15	40,000	35,000	46	321,000	34,000	30,000	32	390,000
11, ...	1.04	31,000	30,000	44	261,000	37,000	36,000	37	355,000
12, ...	1.01	30,000	30,000	41	253,000	39,000	39,000	40	354,000
13, ...	0.44	13,000	30,000	18	268,000	13,000	30,000	14	338,000
14, ...	0.70	14,000	20,000	22	232,000	13,000	19,000	14	338,000
15, ...	0.55	17,000	31,000	28	220,000	15,000	27,000	18	300,000
16, ...	0.64	21,000	33,000	35	221,000	16,000	25,000	18	330,000
17, ...	1.43	33,000	23,000	38	313,000	50,000	35,000	37	494,000
Stump bed, .	1.52	25,000	16,000	18	498,000	49,000	32,000	30	598,000
Average, .	1.11	30,000	28,000	38	291,000	35,000	32,000	33	383,000

Quantity of Sewage applied to Framingham Filter Beds — Concluded.

Number of Bed.	Size of Bed (Acres).	1902. Average Quantity of Sewage applied. Gallons per Day.	1902. Average Quantity of Sewage applied. Gallons per Day per Acre.	1902. Number of Doses.	1902. Average Size of Dose (Gallons).	1903. Average Quantity of Sewage applied. Gallons per Day.	1903. Average Quantity of Sewage applied. Gallons per Day per Acre.	1903. Number of Doses.	1903. Average Size of Dose (Gallons).
1, ...	1.16	29,000	25,000	33	322,000	59,000	51,000	62	347,000
2, ...	1.30	41,000	32,000	44	345,000	62,000	48,000	69	328,000
3, ...	1.30	47,000	36,000	48	360,000	31,000	24,000	37	310,000
4, ...	1.30	40,000	31,000	40	362,000	51,000	39,000	43	429,000
5, ...	1.30	27,000	21,000	30	324,000	34,000	26,000	36	348,000
6, ...	1.13	31,000	27,000	37	305,000	43,000	38,000	43	363,000
7, ...	1.63	60,000	52,000	57	380,000	55,000	35,000	43	478,000
8, ...	1.15	53,000	46,000	60	385,000	44,000	39,000	47	346,000
9, ...	1.15	50,000	44,000	48	379,000	53,000	46,000	53	366,000
10, ...	1.15	50,000	44,000	41	448,000	36,000	32,000	36	370,000
11, ...	1.04	25,000	24,000	27	344,000	23,000	22,000	26	320,000
12, ...	1.01	20,000	20,000	21	351,000	25,000	24,000	28	321,000
13, ...	0.44	9,000	23,000	11	286,000	13,000	30,000	15	321,000
14, ...	0.70	4,000	6,000	5	310,000	16,000	23,000	18	320,000
15, ...	0.55	15,000	27,000	16	351,000	14,000	25,000	17	299,000
16, ...	0.64	17,000	27,000	17	354,000	15,000	23,000	17	315,000
17, ...	1.43	36,000	25,000	30	441,000	34,000	24,000	33	380,000
Stump bed, .	1.52	21,000	14,000	15	513,000	42,000	28,000	30	515,000
Average, .	1.11	32,000	29,000	32	364,000	36,000	32,000	36	360,000

Very little solid matter is removed from the surfaces of the beds, except occasionally in the spring at low points which receive an unusual quantity of sewage.

In the spring the beds are plowed and planted with corn, and after this the only attention which they receive is that which is necessary in caring for the crop and keeping the embankments in good condition. In the fall the corn is harvested, the stalks being cut off about 6 inches above the ground, and nothing further is done to the surfaces of the filter beds to prepare them for winter. Ice collects upon the surface, resting upon the tops of the corn hills, and the sewage passes beneath in the hollows between the hills. No trouble has ever been experienced from the freezing of the beds in winter, notwithstanding that the average minimum daily temperature of the air has been as low as 8.2° F. during the two coldest winter months, with minimum temperatures often ranging more than 10° below zero.

The average temperature of the sewage applied to the beds is high, especially during the winter months, due probably in part to the high temperature of the water supply of the town, which is taken from the ground, and in part to the discharge of considerable quantities of manufacturing wastes having a high temperature into the sewers. The temperature of the sewage as applied to the beds has been observed daily since 1898 by the superintendent of sewers and the average results are given in the following table: —

Average Temperature of Sewage applied to Framingham Filter Beds.

Month.	Degrees F.					
	1898.	1899.	1900.	1901.	1902.	1903.
January,	57	52	47	48	47	45
February,	57	52	46	46	46	45
March,	57	46	45	46	46	45
April,	57	45	49	48	48	47
May,	57	54	53	49	50	45
June,	58	56	56	51	53	48
July,	60	57	58	54	54	56
August,	62	61	60	55	54	60
September,	63	63	62	55	56	59
October,	61	61	59	55	61	58
November,	58	57	57	55	56	57
December,	55	53	53	51	49	56

Character of the Sewage.

The sewage of Framingham is very strong, especially in the summer season, when it is affected but little by leakage or surface water. It changes considerably in character in its course from the sewers through

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the reservoir, pumps and force mains to the filtration area. It is often deeply colored by dye liquors.

As in most of the places where sewage is collected during a part of the time in a reservoir and pumped during another part of the 24 hours to the filtration area, the sewage delivered at the filtration area varies considerably in strength during the day, the strongest sewage being that which has remained in the force main over night and is delivered at the filter beds when pumping begins in the morning, and the weakest being that which succeeds the emptying of the force main, consisting chiefly of the night sewage.

The average character of the sewage, as shown by chemical analyses of monthly samples, is given in the following table: —

Yearly Averages of Chemical Examinations of Sewage from Framingham.

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Oxygen Consumed.	
	Total Residue.			Loss on Ignition.			Free.	Albuminoid.					
	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.		Total.	Dissolved.	Suspended.		Unfiltered.	Filtered.
1893, . .	57.90	33.80	24.10	30.37	10.95	19.42	2.03	0.40	.21	0.19	5.22	-	-
1894, . .	57.70	33.78	23.92	31.17	10.83	20.34	2.44	0.51	.25	0.26	5.86	4.06	2.57
1895, . .	75.95	29.54	46.41	48.92	9.44	39.48	2.72	0.70	.22	0.48	5.48	5.91	2.24
1896, . .	246.26	37.63	208.63	199.82	13.08	186.74	2.86	2.73	.34	2.39	7.23	15.92	2.95
1897, . .	399.57	56.88	342.69	341.08	22.70	318.38	3.14	2.88	.42	2.46	11.56	23.23	3.51
1898, . .	216.00	43.32	172.68	156.69	14.86	141.83	3.10	3.14	.61	2.53	8.45	25.29	4.17
1899, . .	103.10	36.46	66.64	67.63	11.73	55.90	2.64	1.02	.38	0.64	6.42	9.79	3.13
1900, . .	141.78	33.09	108.69	103.44	11.42	92.02	2.79	2.06	.34	1.72	5.84	9.17	2.85
1901, . .	69.83	30.15	39.68	42.88	11.10	31.78	2.84	1.20	.33	0.87	5.19	6.58	2.47
1902, . .	38.48	29.67	8.81	16.55	10.90	5.65	2.77	0.47	.29	0.18	5.44	3.63	2.43
1903, . .	58.77	37.53	21.24	29.88	13.66	16.22	3.17	0.79	.41	0.38	6.99	4.73	2.73

Character of the Effluent.

The effluent delivered to the brook by the underdrains is quite thoroughly purified, while that entering directly from the ground, as shown by the results of analyses of the water of the springs, has the appearance of spring water and is very thoroughly purified. The water of one of these springs is used for drinking purposes by those employed at the filtration area.

The yearly averages of monthly samples of the effluent from these works collected from the two principal underdrains and from a spring near Bannister Brook are given in the following tables: —

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Yearly Averages of Chemical Examinations of Effluent from the East Underdrain of the Framingham Filter Beds.

[Parts per 100,000.]

Year.	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
1893,	.03	24.70	.1786	.0095	3.85	1.2202	.0074	-	5.6	.0114
1894,	.03	25.84	.0467	.0089	4.37	1.0754	.0032	.12	5.5	.0103
1895,	.04	29.15	.2563	.0085	4.78	1.2235	.0057	.16	6.7	.0137
1896,	.02	26.47	.2067	.0109	5.24	0.7683	.0029	.15	6.5	.0048
1897,	.03	35.01	.1426	.0125	8.34	0.9862	.0044	.15	7.6	.0026
1898,	.13	32.87	.6386	.0176	6.74	1.0533	.0035	.18	7.4	.0291
1899,	.08	32.26	.3107	.0172	6.25	1.4008	.0046	.23	6.7	.0240
1900,	.10	34.43	.3402	.0260	6.29	1.3496	.0123	.30	6.8	.0316
1901,	.21	28.58	.2941	.0229	5.81	0.7775	.0052	.29	5.5	.0482
1902,	.13	28.14	.3004	.0211	5.49	1.7725	.0136	.24	6.7	.0288
1903,	.17	29.15	.2359	.0226	5.32	1.0021	.0174	.32	6.2	.0444

Yearly Averages of Chemical Examinations of Effluent from the West Underdrain of the Framingham Filter Beds.

1893,	.04	23.55	.1071	.0080	3.64	1.0360	.0045	-	5.3	.0098
1894,	.02	27.00	.0812	.0070	4.17	1.1959	.0019	.12	6.1	.0070
1895,	.09	25.24	.2145	.0084	4.47	0.9098	.0048	.19	5.9	.0542
1896,	.07	25.89	.0658	.0106	4.74	0.7412	.0030	.16	6.4	.0312
1897,	.14	28.87	.1241	.0179	6.39	0.7115	.0027	.23	6.6	.0152
1898,	.12	26.63	.3276	.0162	5.80	0.7625	.0026	.24	5.9	.0242
1899,	.05	28.18	.1302	.0120	5.64	1.2342	.0042	.20	6.3	.0080
1900,	.08	30.94	.2586	.0171	5.81	1.3250	.0988	.23	6.8	.0301
1901,	.16	28.77	.3963	.0236	5.66	0.9862	.0058	.30	5.8	.1079
1902,	.11	23.89	.3038	.0180	4.95	1.1704	.0222	.27	5.9	.0272
1903,	.10	27.87	.1979	.0147	5.03	0.9687	.0129	.21	6.7	.0278

Yearly Averages of Chemical Examinations of Water from a Spring near Bannister Brook which receives Effluent from the Framingham Filter Beds.

1893,	.00	13.45	.0001	.0014	2.76	0.5095	.0000	-	3.6	.0030
1894,	.01	18.37	.0004	.0023	3.13	0.8319	.0000	.02	4.4	.0030
1895,	.00	18.71	.0001	.0018	3.31	0.7856	.0000	.03	4.6	.0008
1896,	.00	19.02	.0003	.0030	3.43	0.6415	.0000	.04	4.9	.0064
1897,	.01	19.70	.0006	.0029	3.78	0.5671	.0001	.02	6.1	.0007
1898,	.01	20.37	.0010	.0092	4.16	0.5862	.0000	.06	5.1	.0025
1899,	.01	18.65	.0006	.0029	3.78	0.7208	.0000	.03	4.4	.0033
1900,	.00	20.49	.0007	.0051	4.23	0.8314	.0000	.05	4.9	.0055
1901,	.00	18.79	.0007	.0037	3.60	0.6794	.0000	.04	4.5	.0052
1902,	.00	21.40	.0007	.0051	4.22	1.0504	.0000	.06	5.1	.0051
1903,	.00	21.06	.0004	.0018	3.81	0.9100	.0000	.04	4.9	.0053

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Purification effected by the Framingham Sewage Filters.

From the results of the yearly averages of analyses of sewage and effluent given in the preceding tables the percentages of organic matters removed in the process of filtration, as shown by the free ammonia, albuminoid ammonia and oxygen consumed, have been calculated and are presented in the following table. Tables are also appended, showing, in a similar way, the purification effected in the six warmer months of the year, from June to November, inclusive, and in the six colder months, from December to May, inclusive. Tables are also appended showing the purification effected by the Framingham filters, using calculated analyses of the effluent instead of the actual analyses, in order to make allowance for admixture of ground water with the effluent.

Purification effected by the Sewage Filters at Framingham.

East Underdrain.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1893,	2.03	.1786	91.1	0.40	.0095	97.6	-	-	-
1894,	2.44	.0467	98.1	0.51	.0069	98.3	4.06	.12	97.0
1895,	2.72	.2563	90.6	0.70	.0085	98.8	5.91	.16	97.3
1896,	2.86	.2067	92.8	2.73	.0109	99.6	15.92	.15	99.1
1897,	3.14	.1426	95.5	2.88	.0125	99.6	23.23	.15	99.4
1898,	3.10	.6386	79.4	3.14	.0176	99.4	25.29	.18	99.3
1899,	2.64	.3107	88.2	1.02	.0172	98.3	9.79	.23	97.6
1900,	2.79	.3402	87.8	2.06	.0260	98.7	9.17	.30	96.7
1901,	2.84	.2941	89.6	1.20	.0229	98.1	6.58	.29	95.6
1902,	2.77	.3004	89.2	0.47	.0211	95.5	3.63	.24	93.4
1903,	3.17	.2359	92.6	0.79	.0226	97.1	4.73	.32	93.2

West Underdrain.

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1893,	2.03	.1071	94.7	0.40	.0080	98.0	-	-	-
1894,	2.44	.0812	86.7	0.51	.0070	98.6	4.06	.12	97.1
1895,	2.72	.2145	92.2	0.70	.0084	98.8	5.91	.19	96.8
1896,	2.86	.0658	97.7	2.73	.0106	99.6	15.92	.16	99.0
1897,	3.14	.1241	96.0	2.88	.0179	99.4	23.23	.23	99.0
1898,	3.10	.3276	89.5	3.14	.0162	99.5	25.29	.24	99.1
1899,	2.64	.1302	95.1	1.02	.0120	98.8	9.79	.20	98.0
1900,	2.79	.2586	90.7	2.06	.0171	99.2	9.17	.23	97.5
1901,	2.84	.3963	86.0	1.20	.0236	98.0	6.58	.30	95.4
1902,	2.77	.3038	89.0	0.47	.0180	96.2	3.63	.27	92.6
1903,	3.17	.1979	93.8	0.79	.0147	98.1	4.73	.21	95.6

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Purification effected by the Sewage Filters at Framingham during the Summer Months (from June to November, inclusive) of Each Year.

East Underdrain.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1900,	3.38	.1858	94.5	3.50	.0210	99.4	13.84	.24	98.3
1901,	2.92	.1755	94.0	1.84	.0195	98.9	9.92	.25	97.5
1902,	3.40	.2102	93.8	0.46	.0208	95.5	3.42	.25	92.7
1903,	3.80	.2385	93.7	0.81	.0260	96.8	5.22	.33	93.7

West Underdrain.

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1900,	3.38	.2167	93.6	3.50	.0166	99.5	13.84	.20	98.6
1901,	2.92	.2513	91.4	1.84	.0167	99.1	9.92	.23	97.7
1902,	3.40	.2702	92.1	0.46	.0166	96.4	3.42	.25	92.7
1903,	3.80	.1631	95.7	0.81	.0113	98.6	5.22	.19	96.4

Purification effected by the Sewage Filters at Framingham during the Winter Months (from December to May, inclusive) of Each Year.

East Underdrain.

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1900,	2.36	.4820	79.6	0.68	.0310	95.4	4.94	.34	93.2
1901,	2.57	.3887	84.9	0.53	.0257	95.2	3.18	.32	89.9
1902,	2.21	.4207	81.0	0.48	.0223	95.4	3.85	.28	92.7
1903,	2.14	.1732	91.9	0.67	.0175	97.4	3.37	.25	92.6

West Underdrain.

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1900,	2.36	.2746	88.4	0.68	.0149	97.8	4.94	.23	95.3
1901,	2.57	.5513	78.5	0.53	.0313	94.1	3.18	.36	88.7
1902,	2.21	.3420	84.5	0.48	.0195	95.9	3.85	.31	91.9
1903,	2.14	.2330	89.1	0.67	.0189	97.2	3.37	.23	93.2

Purification effected by the Sewage Filters at Framingham as indicated by the Calculated Analyses of the Effluent.

East Underdrain.

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1900,	2.79	.3402	87.8	2.06	.0260	98.7	9.17	.30	96.7
1901,	2.84	.2941	89.6	1.20	.0229	98.1	6.58	.29	95.6
1902,	2.77	.3004	89.2	0.47	.0211	95.5	3.63	.24	93.4
1903,	3.17	.3137	90.1	0.79	.0301	96.2	4.73	.43	90.9

West Underdrain.

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1900,	2.79	.2595	90.7	2.06	.0172	99.2	9.17	.23	97.5
1901,	2.84	.3963	86.0	1.20	.0236	98.0	6.58	.30	95.4
1902,	2.77	.3353	87.9	0.47	.0199	95.8	3.63	.30	91.7
1903,	3.17	.2791	91.2	0.79	.0207	97.4	4.73	.30	93.7

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Bannister Brook, which receives the effluent from the underdrains of the Framingham sewerage system, is a tributary of the Sudbury River, entering that stream near Saxonville, and samples of its water have been collected in the summer months for several years above the point where it receives the effluent from the Framingham sewerage system. The effluent from the Natick filter beds enters the stream above the point where the upper samples were collected, and the sewage from that system is sometimes very imperfectly purified. At times in the winter and spring crude sewage has been discharged into the brook from the Natick filtration area. The brook has a drainage area, where it receives the Framingham effluent, of about 2 square miles. Below this point it flows through meadow land for a distance of about 2 miles to the Sudbury River, receiving, at a point about three-quarters of a mile below the filtration area, the overflow from Lake Cochituate when water is wasting from that source. Between this point and the Sudbury River the stream passes through a large mill-pond, and there is but little population in the neighborhood of the stream between the Framingham filters and the Sudbury River. No complaint has ever been made of the condition of the stream.

Cost of the Works.

The cost of construction of the purification works of Framingham cannot be accurately presented, since the accounts kept by the town cannot be classified. So far as can be determined, the cost is given in the following table: —

Reservoir (capacity 431,000 gallons) and force main,	$38,475 00
Pumping station,	15,705 00
Pumping machinery (capacity 2,000,000 gallons per day),	6,540 00
Land for filter beds (100 acres),	5,775 00
Construction of filter beds (20 acres),	10,000 00
Total,	$76,495 00

The area purchased by the town contained a large growth of wood which was sold for $1,350.50, allowance for which has not been made in the cost of the land given above.

Cost of Maintenance of the Filter Beds.

The cost of maintenance of the filter beds is difficult to ascertain, since a force of men is employed at all times in sewer work and this force is employed at the filtration area for such periods as may be necessary to keep the beds in order, no record being kept of the time so spent.

The crop of corn raised on the filter beds each year is sold at auction standing, and the amount received in the past six years for the corn grown on about 18 acres is as follows: —

	FRAMINGHAM.
1898,	$235 80
1899,	464 75
1900,	462 00
1901,	535 50
1902,	465 25
1903,	337 50

The net receipts were somewhat less than the amounts given above on account of the cost of selling which, in the year 1903, amounted to ten per cent. of the price received.

At the pumping station an engineer and fireman have been employed, and the cost of labor, fuel and repairs is given in the following table: —

1900,	$4,031 62
1901,	4,150 23
1902,	3,945 69

Gardner.

Population in 1900, 10,813.

The town is situated partly within the water-shed of the Nashua River and partly in that of the Miller's, the densely populated portion being within the water-shed of the tributaries of the Miller's River. The population is contained principally in four contiguous villages known as Gardner, West Gardner, Gardner Depot and South Gardner.

Pond Brook, a tributary of the Otter River, one of the head waters of the Miller's River, flows through the central portion of the main village, receiving the overflow from Crystal Lake, situated just north of the thickly settled part of the town. The densely populated portions of the main village and of the village of Gardner Depot are located in the valley of this brook and its tributaries. South Gardner is situated in the valley of the Otter River above Pond Brook, while the principal part of West Gardner drains naturally toward the Otter River below Pond Brook. The topography of the town is very uneven, and the villages are built largely on the slopes of steep hills.

A public water supply was introduced into the town in 1882 from Crystal Lake, and at the end of 1903 there were 28 miles of street mains in use, with which there were 1,323 connections. The public water supply has been extended to all the villages, and the average daily quantity of water used in 1903 was 973,000 gallons, amounting to about 83 gallons per inhabitant.

Sewerage System.

A sewerage system was constructed in 1891 for the collection and disposal of the sewage of the main village, the village of Gardner Depot and a portion of the village of West Gardner in the valley of Pond Brook. By this system the sewage of these villages is collected in pipe sewers and

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conveyed by gravity to a filtration area located in the valley of Pond Brook south of the villages, where it is applied to sand filters after the removal of a portion of the solid matter by sedimentation, the effluent being discharged into Pond Brook.

In 1901 a second system of sewers was constructed to serve West Gardner, and a portion of the sewage of that village which had been discharged into the old system was diverted into the new system. The sewage collected in this system is conveyed in a south-westerly direction across the Otter River to land near the river in Templeton, where it is purified by intermittent filtration, after a portion of the solid matter has been removed by straining the sewage through coke.

The total length of sewers constructed to the end of the year 1903 was 15.4 miles, of which about 8 miles were connected with the old system and 7.4 with the new West Gardner system, and there were 627 buildings connected with the sewers, which may be roughly classified as follows: —

	Gardner System.	West Gardner System.
Dwelling houses,	254	268
Blocks,	8	61
Factories,	4	10
Hotels,	2	4
Schoolhouses,	4	4
Miscellaneous,	5	3
Total connections,	277	350

The total population connected with the sewers at the end of 1903 is estimated to be about 8,000, of which about 3,500 are connected with the Gardner system and 4,500 with the West Gardner system.

Quantity of Sewage.

There are many factories in Gardner, sewage from which is discharged into the sewerage systems, but very little manufacturing waste is discharged from these establishments. A creamery connected with the old system, however, discharges at times much liquid waste into the sewers, and the sewage at such times has a very offensive odor.

The sewers are designed to receive house sewage only, but a few roofs have been connected with the sewers at the ends of branch lines for flushing purposes.

Much water was encountered in the ground when the sewers were constructed, and considerable care was taken to prevent the entrance of ground water through the joints of the pipes; but when the level of the ground water is high the flow of sewage is greatly increased, evidently by leakage

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into the sewers, and there is a marked increase at times of rain, due evidently to the storm-water connections.

No records of the flow of sewage have been kept by the town, but measurements have been made by the State Board of Health at different times and under different conditions, which show approximately the flow of sewage in each of the systems.

During much of the time in the years from 1901 to 1903, inclusive, the sewage from the older or Gardner system was measured by a weir at the settling tank upon the filtration area, and the height of sewage on the weir recorded automatically, so that a practically continuous record of the flow from this system is available during those years. A few measurements have also been made of the flow from the West Gardner system.

A summary of the results of the measurements in 1903 is given in the following tables : —

Flow of Sewage from the Gardner Sewers during the Year 1903, as shown by the Automatic Records of the State Board of Health.

Month.	Gallons per Day.			Month.	Gallons per Day.		
	Average.	Maximum.	Minimum.		Average.	Maximum.	Minimum.
January, . . .	271,000	365,000	218,000	August, . . .	236,000	263,000	208,000
February, . . .	366,000	620,000	276,000	September, . .	228,000	260,000	201,000
March, . . .	563,000	832,000	341,000	October, . . .	263,000	387,000	199,000
April, . . .	457,000	711,000	210,000	November, . .	201,000	262,000	174,000
May, . . .	196,000	262,000	154,000	December, . .	-	-	-
June, . . .	304,000	670,000	148,000				
July, . . .	241,000	301,000	195,000	Year, . .	302,000	832,000	148,000

Flow of Sewage from the West Gardner Sewers during the Year 1903, as shown by Measurements made by the State Board of Health.

Date.	Average Flow (Gallons per Day).	Date.	Average Flow (Gallons per Day).
1903.		1903.	
April 8-9, ...	350,000	June 29-30, ...	254,000

Judging from these and other measurements, the average daily flow of sewage in the year 1903 was about 300,000 gallons in the Gardner system and in the neighborhood of 250,000 gallons in the West Gardner system. The maximum flow in the Gardner system was 832,000 gallons per day.

The average daily flow from both systems per inhabitant during 1903 was 47 gallons. The daily flow per person connected with the sewer, etc., for the year 1903, computed from the records thus far made, is shown in the following table : —

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Gardner System.

	Gallons per Day.		
	Average.	Maximum.	Minimum.
Total flow,	302,000	832,000	148,000
Flow per person connected with the sewer,	86	238	42
Flow per connection,	1,090	3,000	534
Flow per mile of sewer,	37,750	104,000	18,500

West Gardner System.

Total flow,	250,000	-	-
Flow per person connected with the sewer,	55	-	-
Flow per connection,	714	-	-
Flow per mile of sewer,	33,784	-	-

As before stated, the original filtration area was constructed in 1891 in the valley of Pond Brook, and an additional area was constructed in the valley of the Otter River in the town of Templeton in 1901 to serve the western section of the town, the sewage from which could not well be brought to the original area. The old area is locally known as the Gardner area and the new area receiving the sewage of West Gardner as the Templeton area, and they will be so referred to in this report.

At the time the Templeton area was constructed plans were made for diverting a part or all of the flow from the Gardner area to the new Templeton area whenever it should become necessary. At the end of 1903 these works had not been constructed, but provision was made for their construction early in 1904.

The main sewer conveying the sewage to the Gardner area crosses the valley of Pond Brook near the area by means of an inverted siphon, the valley of the brook being at a considerably lower level than the filtration area. This siphon is 1,050 feet long, and is constructed of cast-iron pipe 12 inches in diameter, the difference in elevation between the upper and lower ends of the siphon being 1.4 feet and the maximum dip about 25 feet. At the lowest point in the pipe where it crosses the brook a gate and blow-off are inserted and a small filter bed constructed near the bank of the brook to receive the contents of the siphon whenever it is necessary to empty it or remove any solid matter which may collect there. This gate and filter bed have rarely been used, and no stoppages have occurred in the siphon requiring the use of this blow-off.

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At times the flow through the siphon is somewhat diminished by the collection of matters at the low point, and at such times the sewage backs up somewhat in the main sewer at the upper end of the siphon. Sufficient head is quickly acquired, however, to force out the obstruction, and at times large sticks and other substances which have accidentally found their way into the sewers have been forced out of the siphon in this way.

The siphon receives the flow of sewage as it comes, and there is no screen at the upper end or provision for holding back the sewage for flushing purposes. This siphon holds about 6,200 gallons, and, with the average flow, the sewage is about thirty minutes in passing through, the velocity at such times being about .6 of a foot per second. At times of very low flow the velocity is reduced to about half that rate, while at times of high flow it is about 1.6 feet per second.

Treatment of the Sewage before Filtration (*Gardner System*).

The sewage discharges at the filtration area into two settling tanks, having a combined capacity of about 10,000 gallons. These tanks are each 20 feet in length and 7 feet in width, and contain a depth of about 5 feet of sewage. They are constructed of masonry in duplicate, so that one can be used while the other is being cleaned, and are covered by a wooden building. Under ordinary conditions the flow of sewage is divided, part of it passing into each tank. When both tanks are in use the sewage may be a little over one and one-half hours in passing through the tanks at times of low flow, while at times of maximum flow the sewage may pass through in somewhat less than twenty minutes.

The solid matter which accumulates in the tanks is discharged upon two sludge beds prepared for the purpose. These beds have an aggregate area of .17 of an acre, and were prepared, like the filter beds, by the removal of the surface soil and by underdrainage.

The settling tanks are emptied about once a week, and it has been found that from 6 inches to a foot of solid matter has accumulated in the bottom in that time. The sludge discharged on the beds is allowed to remain until it becomes sufficiently dry so that it can be raked up, when it is removed and much of it used as a fertilizer. The quantity of dry sludge removed from the sludge beds is estimated to be about 200 cubic yards. In winter the solid matter accumulates upon the sludge beds, and the deposit in the spring sometimes amounts to a depth of nearly a foot of dry sludge on each of the beds. The odor in the vicinity of the sludge beds is offensive, but these beds are located in the portion of the filtration area most remote from the village.

From the settling tanks the sewage flows directly to the filtration area.

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Description of the Filter Beds (Gardner System).

The area purchased by the town for filtration purposes comprises 19.4 acres on the north-westerly side of Pond Brook, south of the main highway leading from South Gardner to East Templeton. There is one dwelling house upon the area, which is occupied by the man in charge of the filter beds, and there is one other dwelling house within 200 feet of the filter beds. Within a distance of half a mile there are 90 houses, including a schoolhouse. Many of these buildings have been constructed since the area was first used for the disposal of sewage.

The land purchased by the town comprised a small hill or knoll, the highest point of which was near the middle of the area. Much of the soil was found to be fine, and unsatisfactory for filtration purposes; but some of the material was excellent, and this material was used in the construction of the filters.

Upon this area 21 filter beds, exclusive of the sludge beds, have been prepared for the purification of the sewage, the aggregate area of the filters being 2.5 acres. The beds vary in size from .05 of an acre to .21 of an acre, the average area being .12 of an acre.

On account of the variable character of the soil in different parts of the area, it was necessary to handle all of the material of which the beds were constructed, making the cost of the filters large; but the work was done thoroughly, and their capacity is larger than that of most other filter beds.

The character of the filtering material, as shown by analyses of samples of soil collected from the middle of each of the beds, is shown in the following table: —

Analyses of Filtering Material of the Gardner Filter Beds.

Depth Below Surface (Feet).	Effective Size (Millimeters).			Uniformity Coefficient.			Albuminoid Ammonia (Parts per 100,000).		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
Surface,	.18	.26	.14	4.4	6.0	2.8	51.5	65.9	22.2
0.25,	.18	.25	.13	4.2	5.6	2.8	48.8	71.9	31.0
0.50,	.17	.26	.12	4.4	7.8	2.3	42.1	62.8	21.0
1.00,	.18	.33	.10	4.3	7.4	2.6	29.7	64.5	9.8
2.50,	.15	.21	.12	4.7	6.8	2.8	18.0	38.9	4.9
4.00,	.12	.18	.02	8.0	24.0	2.5	15.5	37.7	5.1

Underdrainage (Gardner System).

The filter beds are thoroughly underdrained by lines of pipe laid 20 feet apart at distances of about 5 feet beneath the surface. These drains discharge through one main underdrain directly into Pond Brook.

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Method of Operating the Filters (Gardner System).

The sewage as it flows from the tanks is applied to some of the filter beds through openings in a wooden trough which runs across the ends of several beds at a considerable elevation above their surfaces. In order to prevent the washing away of sand beneath the openings, the portion of the bed where the sewage falls upon it is paved with cobble stones. The sewage is distributed on the other beds through pipes discharging at one point on the side of each bed.

The beds are arranged largely in terraces around the southerly and easterly side of the knoll upon the top of which the settling tank is located, and for convenience an overflow has been provided from each bed to the next below or to an adjacent bed, the overflow from the lowest beds discharging into the brook.

During the summer it has been the custom to rake each filter bed at intervals of about two weeks, and the material removed is used as a fertilizer. Although a portion of the solid matter is removed from the sewage in the settling tanks before the sewage is applied to the filter beds, a large quantity is removed from the beds at each raking. The material dries in such a manner that it is easily raked up, excepting in winter. The beds are harrowed about three times each season. In the fall they are plowed and left in furrows and ridges, so that the ice and snow will rest upon the ridges and protect the sewage in the hollows from the action of the frost. Repeated examinations during the coldest winter weather have shown that, although sewage was being applied at a very low temperature, the sand was free from frost at all times.

During the winter months it is impracticable to clean the surfaces of the filter beds, which become clogged to such an extent that very little sewage passes through them; and the sewage is then discharged into the brook, after passing over one or more of the filter beds for the removal of as much as possible of the solid matter. In the spring the beds are dried with much difficulty, since they become thoroughly clogged during the winter season, and the sewage continues to flow into the brook until the beds have been cleaned. This discharge into the brook takes place in the winter and spring at the time when the flow of the brook is highest, but the brook is nevertheless very badly polluted by the sewage.

Observations upon the temperature of the sewage discharged upon the beds show that it averages about 40° F. in the coldest winter weather. Periods of extremely cold winter weather are common, when the maximum temperature remains at about zero F. for several days continuously, with minimum temperatures very much lower.

The custom in regard to the dosing of the beds has changed as the quantity of sewage to be treated has increased. In the beginning, sewage was applied to the beds every other day, and they were allowed to dry

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after each dose of sewage. In recent years, the majority of the beds are much of the time covered with sewage and are dried out only for cleaning purposes. The effect of this management on the purification of the sewage has been unfavorable.

Since the completion of the Templeton area the quantity of sewage flowing to the Gardner area has been about 250,000 gallons per day during ordinary weather, increasing to about 750,000 gallons per day at times of wet weather in the winter and spring. The quantity of sewage applied to the beds, therefore, has amounted during the drier portion of the year to as much as 100,000 gallons per acre per day, while in wet weather the amount has risen to 300,000 gallons per acre per day.

Character of the Sewage (Gardner System).

The sewage of Gardner discharged upon the Gardner area is a strong sewage during the greater portion of the year, notwithstanding its great dilution at times by rain water and ground water. At times quantities of waste from a creamery are discharged into the sewage, giving it a distinctly milky appearance and a very offensive odor.

While the distance from the village to the filter beds is not great, the organic matters in the sewage become well broken up before being discharged upon the filter beds.

The average character of the sewage, as shown by yearly averages of chemical analyses of monthly samples, is given in the following table: —

Yearly Averages of Chemical Examinations of Sewage from Gardner (Gardner System).

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Oxygen Consumed.	
	Total Residue.			Loss on Ignition.				Albuminoid.					
	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.	Free.	Total.	Dissolved.	Suspended.		Unfiltered.	Filtered.
1892,	29.33	19.15	10.18	16.90	8.64	8.26	1.67	.42	.23	.19	2.60	-	-
1893,	33.35	20.90	12.45	19.01	9.22	9.79	1.88	.48	.26	.22	3.48	-	-
1894,	27.00	16.67	10.33	14.60	6.90	7.70	1.57	.37	.20	.17	2.47	3.27	2.13
1895,	32.25	19.76	12.49	18.27	8.56	9.71	1.65	.56	.26	.30	2.76	4.32	2.21
1896,	37.07	21.44	15.63	21.04	9.22	11.82	2.67	.62	.33	.29	3.02	3.94	2.43
1897,	37.83	22.17	15.66	20.92	9.33	11.59	1.69	.71	.47	.24	3.04	4.09	1.92
1898,	36.43	19.67	16.76	20.67	7.64	13.03	2.37	.69	.32	.37	3.09	4.61	2.17
1899,	50.84	24.09	26.75	34.56	10.41	24.15	2.98	.98	.38	.60	4.20	5.73	2.87
1900,	45.68	21.93	23.75	28.43	9.42	19.01	2.43	.86	.32	.54	3.42	5.80	3.02
1901,	30.72	18.87	11.85	17.43	7.85	9.58	1.91	.53	.27	.26	2.81	3.80	2.41
1902,	37.00	24.88	12.12	24.07	13.72	10.35	2.10	.58	.25	.33	2.96	7.11	4.91
1903,	38.37	22.97	15.40	22.93	9.89	13.04	2.45	.60	.35	.25	3.38	4.92	2.82

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Character of the Effluent (Gardner System).

The purification effected by the Gardner filter beds in winter is comparatively small, owing to the fact that the beds are flooded continuously with sewage, and soon become clogged, preventing the entrance of air into the sand. In consequence of this, the effluent has a very noticeable odor and is greatly discolored by iron. During the summer the effluent is of much better quality.

The yearly averages of analyses of monthly samples of the effluent are given in the following table: —

Yearly Averages of Chemical Examinations of Effluent from the Gardner Sewage Purification Works (Gardner System).

[Parts per 100,000.]

Year.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Free.	Albuminoid.		Nitrates.	Nitrites.			
1892,	17.54	0.5112	.0351	2.40	.6768	.0787	-	4.4	-
1893,	14.70	0.4628	.0423	2.03	.7783	.0257	-	4.0	0.0266
1894,	17.03	0.4170	.0403	2.12	.9367	.0253	0.43	4.2	0.0239
1895,	18.44	0.5030	.0552	2.63	.7550	.0119	0.60	4.2	0.1369
1896,	17.50	0.7435	.0767	2.84	.4529	.0186	0.54	4.0	0.1926
1897,	16.49	0.5597	.0505	2.61	.4592	.0109	0.55	4.6	0.0916
1898,	18.82	0.6613	.0645	2.88	.6128	.0159	0.53	4.9	0.2831
1899,	19.91	0.8075	.0825	2.87	.8191	.0392	0.86	4.5	0.2568
1900,	18.77	1.1637	.0975	3.02	.2861	.0231	1.03	3.3	0.5875
1901,	17.06	1.1410	.0808	2.72	.1832	.0355	0.81	3.4	0.4397
1902,	19.20	1.0067	.0874	2.98	.1700	.0195	1.11	3.9	0.8290
1903,	23.48	1.7990	.0841	3.02	.0442	.0047	1.07	6.1	1.3567

Purification effected by the Gardner Sewage Filters (Gardner System).

From the results of the yearly averages of analyses of sewage and effluent given in the preceding tables, the percentages of organic matters removed in the process of filtration, as represented by the free ammonia, albuminoid ammonia and oxygen consumed, have been calculated and are presented in the following table. Tables are also appended, showing, in a similar way, the purification effected in the six warmer months of the year, from June to November, inclusive, and in the six colder months, from December to May, inclusive. Comparatively little ground water, except from the rainfall, finds its way into the underdrains of the Gardner system, so that the flow from the underdrains is almost entirely sewage effluent.

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Purification effected by the Sewage Filters at Gardner (Gardner System).

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1893, ...	1.88	0.4628	75.4	0.48	.0423	91.2	-	-	-
1894, ...	1.57	0.4170	73.4	0.37	.0403	89.1	3.27	0.43	86.9
1895, ...	1.65	0.5030	69.5	0.56	.0552	90.1	4.32	0.60	86.1
1896, ...	2.67	0.7435	72.2	0.62	.0767	87.6	3.94	0.54	86.3
1897, ...	1.69	0.5597	66.9	0.71	.0505	92.9	4.09	0.55	86.6
1898, ...	2.37	0.6613	72.1	0.69	.0645	90.7	4.51	0.53	88.2
1899, ...	2.98	0.8075	72.9	0.98	.0825	91.6	5.73	0.86	85.0
1900, ...	2.43	1.1637	52.1	0.86	.0975	88.7	5.80	1.03	82.2
1901, ...	1.91	1.1410	40.3	0.53	.0808	84.8	3.80	0.81	78.7
1902, ...	2.10	1.0067	52.1	0.58	.0874	84.9	7.11	1.11	84.4
1903, ...	2.45	1.7990	26.6	0.60	.0841	86.0	4.92	1.07	78.3

Purification effected by the Sewage Filters at Gardner during the Summer Months (from June to November, inclusive) of Each Year (Gardner System).

1893, ...	2.24	0.1877	91.6	0.56	0.0255	95.4	4.63	0.35	92.4
1894, ...	1.69	0.1513	91.0	0.42	0.0312	92.6	3.57	0.33	90.8
1895, ...	1.83	0.2540	86.1	0.58	0.0327	94.4	4.57	0.49	89.3
1896, ...	2.57	0.4110	84.0	0.53	0.0503	90.5	3.95	0.43	89.1
1897, ...	1.52	0.2467	83.8	0.68	0.0362	94.7	4.22	0.29	93.1
1898, ...	2.75	0.3567	87.0	0.81	0.0431	94.7	4.81	0.38	92.1
1899, ...	3.14	0.4900	84.4	1.16	0.0615	94.7	5.63	0.68	87.9
1900, ...	2.37	0.5073	78.6	0.73	0.0747	89.8	5.18	0.63	87.8
1901, ...	1.96	0.4817	75.4	0.59	0.0460	92.2	3.57	0.45	87.4
1902, ...	2.26	0.8233	63.6	0.48	0.0817	83.0	4.12	0.74	82.0
1903, ...	2.66	2.1267	20.0	0.65	0.0713	89.0	5.02	1.19	76.3

Purification effected by the Sewage Filters at Gardner during the Winter Months (from December to May, inclusive) of Each Year (Gardner System).

1893, ...	1.48	0.7163	51.6	0.41	0.0596	85.5	2.74	0.79	71.2
1894, ...	1.46	0.6860	53.0	0.26	0.0462	82.2	3.02	0.52	82.8
1895, ...	1.44	0.7587	47.3	0.44	0.0763	82.7	4.11	0.69	83.2
1896, ...	2.80	1.0767	61.5	0.67	0.0767	88.6	3.51	0.67	80.9
1897, ...	1.97	0.8967	54.5	0.75	0.0838	88.8	4.61	0.80	82.6
1898, ...	1.92	0.9927	48.3	0.57	0.0933	83.6	3.77	0.68	82.0
1899, ...	2.57	0.9867	61.6	0.77	0.0877	88.6	5.89	0.91	84.6
1900, ...	2.68	1.8627	30.5	0.60	0.1283	78.6	5.48	1.48	73.0
1901, ...	1.89	1.8087	4.3	0.92	0.1187	87.1	4.73	1.09	77.0
1902, ...	1.72	1.1617	32.5	0.54	0.0924	82.9	5.37	1.58	70.6
1903, ...	2.52	1.3647	45.8	0.61	0.0938	84.6	9.18	0.88	90.4

Cost of the Works (Gardner System).

The cost of the filtration area and of the filter beds is given in the following table, prepared from the annual reports of the sewer commissioners: —

Land (19.4 acres),	$3,000
Constructing filter beds (2.67 acres),	18,850
Settling tanks,	1,102
Siphon,	1,847
Total,	$24,799

Cost of Maintenance of the Filters (Gardner System).

The beds are cared for by one man, who gives his entire time to the work and is occasionally assisted by a second man. A horse is used for several days in the fall and spring, when the beds are being prepared for winter or are being cleaned and levelled for summer.

The cost of maintenance for each year during which the beds have been operated, which is given in the following table, is taken from the reports of the sewer commissioners: —

1892,	$421 21	1898,	$889 35
1893,	474 50	1899,	689 33
1894,	485 37	1900,	577 02
1895,	469 50	1901,	618 55
1896,	549 50	1902,	563 80
1897,	635 12	1903,	1,070 00

The cost for 1903 is uncertain, since the accounts for the maintenance of the two filtration areas are not kept separate.

The average amount realized annually from the sale of grass growing upon this area during the last five years has been $45.

When the scheme for disposing of the sewage of the westerly part of Gardner in Templeton was designed, provision was made for diverting a part or all of the sewage now flowing to the Gardner area to the Templeton area at some subsequent time. Early in 1904 the town appropriated money for the purpose of laying a sewer from the Gardner area to connect with the sewer leading to the Templeton area, so that it is likely that before another year the quantity of sewage discharged upon the Gardner area will be reduced to the quantity which these beds are capable of purifying properly.

Templeton Area.

The main sewer which conveys the sewage to this area crosses the valley of the Otter River by means of an inverted siphon. This siphon is constructed of cast-iron pipe 16 inches in diameter. Its length is 2,600 feet,

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and the lower end is 5.7 feet below its upper end. The lowest point in the siphon is 32.5 feet lower than the lower end. At the upper end of the iron pipe a flush tank was constructed, designed to discharge the sewage intermittently through the siphon. The flush tank was made by enlarging the size of the main sewer from 12 inches to 30 inches for a distance of 427 feet back of the upper end of the inverted siphon, and an automatic apparatus was installed designed to discharge this sewage intermittently.

The quantity of sewage contained in the storage sewer or flush tank at the point at which this automatic siphon is designed to discharge is 19,700 gallons, and the normal length of time of each discharge is about thirteen minutes, with the average flow of sewage, and, under these circumstances, the tank discharges about once in eighty minutes. During much of the time, however, the automatic siphon has not been in operation, and the sewage has flowed continuously through the inverted siphon. It has been customary, however, to operate the flush tank about once in each week, in order to flush out the inverted siphon; and at such times a small amount of solid matter is discharged with the first flush, the sediment consisting chiefly of coffee grounds and other finely divided solid matter. No blow-off is provided at the low point in the siphon where the pipe passes beneath the river, but a 6-inch water main has been connected with the siphon at its upper end, so that water can be discharged into the siphon under pressure if necessary.

The average quantity of sewage flowing from this system is about 250,000 gallons per day, and with this flow the average velocity through the siphon is .34 of a foot per second. When the flush tank is in operation the average velocity is 2 feet per second, being somewhat greater than this during the first part of its operation and somewhat less during the last part.

The inverted siphon holds, when full, about 27,200 gallons, and the quantity of sewage contained in the storage sewer amounts to about 73 per cent. of the capacity of the inverted siphon.

Treatment of the Sewage before Filtration (Templeton System).

The sewage discharges at the filtration area into a small chamber where it passes through a screen constructed of iron bars, with open spaces between them of 1½ inches. The area of this screen is 3.88 square feet.

In order to reduce, so far as practicable, the area of filter beds necessary for purifying the sewage, provision was made when these works were constructed for straining the sewage through coke before applying it to the filters. The coke strainers are four in number, each having an area of ⅛ of an acre, the total area being ½ of an acre. They are constructed of a layer of coke breeze, so called, 8 inches in thickness, which is supported by layers of broken stone, the bottom layer of stone being of such size as

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would pass through a ring 1 inch in diameter, while the upper layer of broken stone upon which the coke rests is composed of stone, all of which would pass through a ring ½ an inch in diameter. The depth of broken stone over the underdrains is 6 inches. The strainers are underdrained by means of tile pipes laid 6 feet apart in the lower layer of broken stone.

The sewage is applied to the strainers through three wooden troughs laid across each of the beds about 1 foot above their surfaces, the sewage discharging through small holes cut through the sides of the troughs at intervals of about 4 feet, from which it falls to the surface of the strainers. In order to prevent disturbance of the coke where the sewage drops on the surface, a pile of stones is placed beneath each hole.

For the purpose of regulating the flow of sewage upon the coke strainers, an automatic apparatus has been installed designed to discharge the flow of sewage upon one of the coke strainers until this strainer has received a certain quantity, when the flow is to be diverted automatically to a second strainer, and so on; while the contents of the first strainer, after standing for a certain length of time, are to be automatically discharged upon one of the sand filter beds. When this apparatus is in operation the flow of sewage can be discharged upon each of the strainers in succession, each strainer receiving a certain amount of sewage, remaining full for a given period and being emptied automatically and allowed a period of rest before receiving the next dose. The apparatus has not thus far operated satisfactorily and has been in operation only for short periods of a few days occasionally.

The strainers were first put in operation in the fall of 1901. Late in that year the surfaces were partly scraped, the material being gathered in piles, when cold weather came on unexpectedly, and this material remained in piles upon the surfaces of the strainers until spring. The strainers were operated for a time, but their use was subsequently discontinued during the remainder of the winter, and the sewage discharged directly upon the filter beds. During the summer of 1902 the strainers were not used to any considerable extent, as changes were being made in the automatic dosing apparatus. In the fall of that year the strainers were again operated and worked satisfactorily until about the first of March, 1903, when they again became clogged, and their use was again discontinued until warmer weather. During the remainder of the year 1903 they were operated satisfactorily, though the automatic apparatus was used but little.

The results of the operation of these strainers thus far shows that in the warmer part of the year the organic matter which is collected upon their surfaces can be easily rolled up and removed after the bed has been allowed to dry for a sufficient time. During cold weather it is not practicable to dry the strainers sufficiently to remove the material in this way, and no serious attempt has been made to clean the strainers at such times.

When the strainers were installed they were designed to be cleaned by

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removing the organic matter from the surface in a manner somewhat similar to the method used in cleaning water filters; and if this method were adopted, it is probable, from the experience thus far gained, that the strainers would operate satisfactorily at all seasons of the year, as certain days could be selected in the winter when the temperature was above the freezing point when cleaning would be practicable.

The results of analyses of the sewage applied to these strainers and the effluent from them are presented in tables beyond. These tables show that a large proportion of the organic matter is removed from the sewage, but no nitrification takes place in the strainers.

Description of the Filter Beds (Templeton System).

The area purchased by the town for the disposal of the sewage of this system comprises 77 acres, including in part high land containing a sandy soil of excellent quality for the purification of sewage. The area is located in the valley of the Otter River, on the westerly side of the stream, in a very sparsely settled region, the nearest dwelling houses being about 1,000 feet from the filter beds. Practically all of the soil suitable for filtration purposes upon this area was above the level at which it was practicable to deliver the sewage by gravity, and it was deemed best, under the circumstances, to construct the filter beds upon the low lands artificially rather than to pump the sewage. Upon this area nine filter beds have been constructed, each ¼ of an acre in area, making the total area 2.25 acres.

Underdrainage (Templeton System).

The filter beds are underdrained by lines of tile pipe laid 30 feet apart. The depth of the filtering material immediately above the underdrain is about 3½ feet, while midway between the underdrains the depth of the filters is about 2½ feet, the ground upon which the filter beds were constructed having been graded to slope toward the underdrains.

Method of Operating the Filters (Templeton System).

Sewage is applied to the filters through an outlet at the corner of each bed. The sewage discharges into a basin of concrete, the outer rim of which is a segment of a circle. Holes were made through the side of this basin through which the sewage flows upon the beds.

When the flush tank at the upper end of the inverted siphon is not in operation and the sewage is being applied to the beds continuously, it has been the custom once a week to operate the flush tank for the removal of the solid matter which may have accumulated in the inverted siphon; and the sewage discharged from the inverted siphon at such times is put upon one of the filter beds, and a considerable quantity of solid matter accumulates

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upon the surfaces of this bed, especially near the outlet pipe, this material consisting largely of coffee grounds.

When the coke strainers are in operation the filter beds require but very little attention, and very little solid matter collects upon their surfaces. When these strainers are not in operation the filters require occasional cleaning.

In winter the filter beds are furrowed, and no trouble has been experienced in the purification of all of the sewage received at all times, even at times when the coke strainers are not in operation, though the quantity of sewage applied to the filters at such times averages a little over 100,000 gallons per acre per day, and often greatly exceeds this quantity.

Character of the Sewage (Templeton System).

The sewage discharged upon the Templeton area is a strong domestic sewage, very little manufacturing waste being discharged into the sewers.

The average character of the sewage and of the effluent from the coke strainers for the years 1902–3, as shown by chemical analyses of monthly samples, is indicated in the following table: —

Yearly Averages of Chemical Examinations of Sewage and of Effluent from the Coke Strainers at the Gardner Filtration Area (Templeton System).

Entrance to Coke Strainer.

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Oxygen Consumed.	
	Total Residue.			Loss on Ignition.				Albuminoid.					
	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.	Free.	Total.	Dissolved.	Suspended.		Unfiltered.	Filtered.
1902, . .	38.51	26.67	11.84	22.53	13.73	8.80	3.71	.74	.43	.31	4.32	5.23	3.45
1903, . .	43.06	22.88	20.18	26.97	9.21	17.76	3.31	.80	.38	.42	4.38	6.03	2.61
Effluent from Coke Strainer.													
1902, . .	23.26	18.97	4.29	10.29	7.43	2.86	2.55	.38	.26	.12	3.94	2.88	1.95
1903, . .	19.67	17.10	2.57	7.27	5.20	2.07	2.18	.27	.15	.12	3.24	1.76	1.34

Character of the Effluent (Templeton System).

The filter beds were first operated in 1902, and nitrification was slow in beginning, due perhaps to the removal of so large a portion of the solid matter from the sewage by the coke strainers. When sewage was applied directly to the filter beds, nitrification became more active, and since that time the efficiency of the filters has greatly improved.

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The character of the effluent, as shown by yearly averages of monthly samples, is given in the following table : —

Yearly Averages of Chemical Examinations of Effluent from the Gardner Sewage Purification Works (Templeton System).

North Underdrain.

[Parts per 100,000.]

Year.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
1902, ...	25.81	1.4731	.1357	3.79	1.2382	.0115	.93	5.3	.0306
1903, ...	26.10	0.7527	.0748	3.17	1.4389	.0098	.58	5.7	.0341
South Underdrain.									
1902, ...	23.04	1.3492	.1102	3.82	1.1230	.0282	.92	4.3	.0381
1903, ...	25.28	0.7996	.0648	2.92	1.5972	.0295	.58	5.9	.0454

Purification effected by the Gardner Sewage Filters (Templeton System).

From the results of the yearly averages of analyses of sewage and effluent given in the preceding tables, the percentages of organic matters removed in the process of filtration, as represented by the free ammonia, albuminoid ammonia and oxygen consumed, have been calculated, and are presented in the following table. Tables are also appended, showing, in a similar way, the purification effected in the six warmer months of the year, from June to November, inclusive, and in the six colder months, from December to May, inclusive.

Purification effected by the Coke Strainers at Gardner (Templeton System).

[Parts per 100,000.]

Year.	Free Ammonia. Sewage.	Free Ammonia. Effluent.	Free Ammonia. Per Cent. Removed.	Total Albuminoid Ammonia. Sewage.	Total Albuminoid Ammonia. Effluent.	Total Albuminoid Ammonia. Per Cent. Removed.	Oxygen Consumed. Sewage.	Oxygen Consumed. Effluent.	Oxygen Consumed. Per Cent. Removed.
1902, ...	3.71	2.5543	31.2	.74	.3771	49.0	5.23	2.88	44.9
1903, ...	3.31	2.1771	34.2	.80	.2691	66.4	6.03	1.76	70.8

Purification effected by the Coke Strainers and Sewage Filters at Gardner (Templeton System).

1902, ...	3.71	1.4111	62.0	.74	.1229	83.4	5.23	0.92	82.4
1903, ...	3.31	0.7761	76.6	.80	.0598	91.3	6.03	0.58	90.4

GARDNER.

Purification effected by the Coke Strainers and Sewage Filters at Gardner during the Summer Months (from June to November, inclusive) of Each Year (Templeton System).

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1902,	3.89	0.7254	81.4	.73	.0964	86.8	4.90	.80	83.7
1903,	3.50	0.6100	82.6	.73	.0650	91.1	5.00	.59	88.2

Purification effected by the Coke Strainers and Sewage Filters at Gardner during the Winter Months (from December to May, inclusive) of Each Year (Templeton System).

1902,	3.70	2.0183	45.5	.77	.1121	85.4	4.90	.75	84.7
1903,	3.04	1.0283	66.2	.84	.0874	89.6	7.30	.65	91.1

Cost of the Works (Templeton System).

The cost of the coke strainers and filter beds is shown in the following table. The coke for the strainers was obtained in Everett, taken to Gardner by rail (a distance of 65 miles), and hauled about 2 miles to the filtration area. The sand for the filter beds was moved an average distance of about 800 feet.

Land (77 acres),	$4,400 00
Constructing coke strainers (½ acre),	10,946 64
Constructing sand filter beds (2¼ acres),	11,252 72
Constructing siphon,	7,368 01
Constructing storage sewer,	2,930 18
Total,	$36,897 55

About $3,000 in addition has been spent on the coke strainers since they were first built, in rearranging the automatic apparatus for dosing the beds.

Cost of Maintenance of the Filters (Templeton System).

The cost of maintaining the filters has been as follows: —

1902,	$731 66
1903,	849 00

Remarks.

Late in 1903 work was begun upon the construction of a large settling tank, into which it is proposed to discharge the sewage and remove a part of the solid matter by sedimentation before applying it to the coke strainers.

Great quantities of *Leptomitus* grow in the sewers of the West Gardner system, which, becoming detached, tend to clog the coke strainers at certain seasons of the year. By the use of the settling tank it is expected

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to remove much of this matter, in addition to a large quantity of solid matter, and thus reduce materially the quantity of solid matter which will require removal from the surfaces of the strainers.

HOPEDALE.

Population in 1900, 2,087.

The town of Hopedale is situated chiefly within the water-shed of the Mill River, a tributary of the Blackstone River which enters that stream in Rhode Island. The area of the town is quite small, and practically all of the population is contained in the main village located along the river. There is one large factory in the town in which cotton machinery is manufactured, and this factory furnishes employment for nearly the entire working population of Hopedale beside a large number of persons who live in neighboring towns.

A public water supply was introduced about 1881 by the Milford Water Company before the incorporation of Hopedale, which was formerly a part of Milford. The supply is taken in part from the Charles River and filtered through sand, and in part from wells located near the river. No record is kept of the quantity of water supplied to Hopedale, but the quantity supplied per inhabitant to Milford and Hopedale together in 1903 was 53 gallons per day, indicating a consumption of water in Hopedale of about 100,000 gallons per day.

Sewerage System.

The sewerage system was constructed in 1892 by the Draper Company to serve a portion of the village and the large works of the Draper Company. The sewage was in the beginning discharged into Mill River after passing through settling tanks for the removal of a portion of the solid matter. Mill River has a water-shed at Hopedale of about 9.5 square miles, and this method of disposing of the sewage resulted in the gross pollution of the stream. Works for the purification of the sewage were constructed in 1900.

At the present time the sewage is collected in a system of pipe sewers in which it is conveyed to tanks near the river just below the factory of the Draper Company, whence it is pumped to filter beds located on the southerly side of the river a little more than half a mile down stream, where the sewage is applied to filter beds, the effluent finding its way into Mill River.

The sewerage system has been extended throughout the thickly built up portions of the village, and at the end of the year 1903 there were 4 miles of sewers in use and 200 buildings connected with them. The estimated population contributing sewage at the end of the year 1903 is 2,000.

Quantity of Sewage.

The sewerage system was constructed on the separate plan and was designed to receive sewage only, but, judging from observations of the flow,

there is considerable leakage into the sewers, but no continuous measurements have been made which would show the amount of leakage. The sewers are not underdrained.

No records are kept of the quantity of sewage pumped, and the only information available as to the flow of sewage from this system is that which has been obtained by occasional measurements by the State Board of Health. The results of measurements made in 1902 and 1903 are given in the following table:—

Flow of Sewage at Hopedale.

Date.	Gallons per Day.	Date.	Gallons per Day.
April 9-10, 1902,	229,700	July 7-8, 1903,	125,000
April 14-15, 1903,	366,000	July 14-15, 1903,	100,000

It will be seen from the foregoing table that there is a great variation in the quantity of sewage. The only large contributor of sewage is the factory of the Draper Company, which employs ordinarily about 2,000 persons, though in 1903 the number employed was very much smaller. No manufacturing wastes are discharged into the sewers in the town, such waste as comes from the factory consisting of spent acids which are treated separately, the acids being neutralized and then passed through cinder filter beds and discharged into the river.

From the measurements and observations which have been made it is estimated that the average quantity of sewage flowing in dry weather under ordinary conditions is about 150,000 gallons per day, while during wet weather this is increased to at least 400,000 gallons per day.

The following table gives the estimated average and maximum flow of sewage per inhabitant, etc., in the year 1903:—

	Gallons per Day.	
	Average.	Maximum.
Total flow,	150,000	400,000
Flow per inhabitant,	60	159
Flow per person connected with the sewers,	75	200
Flow per connection,	750	2,000
Flow per mile of sewer,	37,500	100,000

Treatment of the Sewage before Filtration.

The tanks into which the sewage is received are constructed in duplicate and are designed to operate as septic tanks. Each tank is divided in the middle by a wall, so that a portion may be used as a pump well and the remaining portion kept full at all times. The portion of each tank used as

a septic tank is 40 feet 9 inches long, 12 feet 6 inches wide and 11 feet 6 inches deep, having a capacity of about 35,000 gallons, or in both tanks, a capacity of about 70,000 gallons. Judging from the measurements of the flow of sewage, the period which would elapse while the sewage is passing through the tanks would be ordinarily from four to eleven hours, when both tanks are in operation.

The pump wells are formed by an extension of each of the septic tanks and are of the same size as the septic tanks, containing together about 70,000 gallons. The tanks are so arranged that the septic tanks can be joined to the pump wells, and all of the tanks used together as a storage reservoir for the flow of night sewage.

The tanks first received the sewage in August, 1900, and a mat formed upon the surface of the septic tanks which continued to grow thicker and became exceedingly compact, and eventually so much organic matter collected in the tanks that it was removed only with great difficulty and at a large expense.

An overflow is provided from the tanks into the river through which sewage may flow in case the tanks become filled when the pumps are not in operation. It has frequently happened in wet weather that this overflow has come into use in the latter part of the night and considerable quantities of sewage have been disposed of by direct discharge into the river through this overflow. Recently an electric motor has been installed, and all of the sewage is pumped to the filter beds except when the tank is being cleaned.

The pump which forces the sewage from the tanks to the filtration area is a 6-inch centrifugal pump, having a capacity of about 1,000,000 gallons a day, located in the factory. The force main from the pump to the filtration area is a cast-iron pipe 10 inches in diameter and 3,263 feet in length, the total rise from the pump well to the filter beds being about 25 feet. The main is so laid that when the pumps are stopped it remains full until pumping is again resumed. This pipe contains, when full, about 13,300 gallons of sewage, and, with the average rate of pumping, the velocity through it is 2.8 feet per second, and the sewage is about nineteen minutes in passing from the pumps to the filtration area.

Description of the Filter Beds.

The area controlled by the company for filtration purposes is located on the southerly side of Mill River, a short distance below the village. The nearest house is about 475 feet from the filter beds, and there are 30 dwelling houses within half a mile of the area.

The area was originally quite uneven in contour, including a knoll which contained considerable gravelly soil but also much ledge and fine material. A portion of the area is quite low, and in this place the soil is, for the most part, fine.

On this area four filter beds have been constructed, and a small sludge bed, each filter bed having an area of approximately half an acre, making the total area of filter beds about 2.3 acres. The sludge bed has an area of about 0.7 of an acre. The sludge bed was constructed for the purpose of receiving any sludge which might accumulate in the septic tanks and require removal, the intention being to open a gate between the septic tanks and the pump well and flush the sludge through to the pump. The solid matter which accumulated in the septic tanks was of such a nature, however, that it would not pass through the gate, and the sludge bed has been used as a filter bed.

The loam and subsoil were removed when the beds were constructed and used to form the embankments about the filter beds. The material of which the filter beds are constructed is variable in character, some portions containing coarse sand, while other portions contain very fine sand. A considerable quantity of ledge was encountered in some portions of the area and was removed by blasting when the beds were constructed.

Underdrainage.

All of the filter beds are underdrained by means of tile pipes laid about 60 feet apart and at a depth of about 4 feet beneath the surface.

Method of Operating the Filters.

The sewage is applied to the filter beds through wooden trough carriers laid across each bed from which sewage is discharged upon the filters through numerous openings in the sides of the carriers. The ordinary method of operation is to discharge the sewage upon two beds each day. In this way each bed receives a dose of from 75,000 to 200,000 gallons per day, the rate of filtration over the entire area being from 65,000 to 175,000 gallons per acre per day.

In summer the beds are raked occasionally and organic matter removed from them. In winter the beds are arranged in furrows and ridges and no difficulty is experienced from the freezing of the filter beds, but in wet weather the quantity of sewage applied to these filters is in excess of their capacity and they are covered with sewage much of the time in the early spring. As already indicated, at such times a considerable quantity of sewage is discharged directly into the river. When the beds are being dried preparatory to cleaning them in the spring, the sewage is discharged on a ploughed field in the vicinity.

Character of the Sewage.

The sewage of Hopedale is strictly a domestic sewage, no manufacturing waste being discharged into the sewers.

HOPEDALE.

Analyses have been made frequently of samples of sewage collected from the end of the force main at the filter beds. The yearly averages of these analyses are presented in the tables which follow.

Yearly Averages of Chemical Examinations of Sewage from Hopedale.

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Oxygen Consumed.	
	Total Residue.			Loss on Ignition.			Free.	Albuminoid.				Unfiltered.	Filtered.
	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.		Total.	Dis-solved.	Sus-pended.			
1901, . .	24.24	17.60	6.64	11.27	7.11	4.16	2.55	.30	.17	.13	2.67	2.61	1.66
1902, . .	21.65	16.00	5.65	10.50	6.30	4.20	2.92	.27	.15	.12	3.36	3.12	1.77
1903, . .	19.67	14.57	5.10	10.43	6.09	4.34	2.22	.34	.22	.12	2.23	2.98	2.07

Character of the Effluent.

The results of analyses of the effluent from the Hopedale filtration area are presented in the following table: —

Yearly Averages of Chemical Examinations of Effluent from the Hopedale Sewage Purification Works.

[Parts per 100,000.]

Year.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Free.	Albuminoid.		Nitrates.	Nitrites.			
1901, ...	20.26	0.8085	.0455	2.62	0.7030	.0086	.40	3.9	.1361
1902, ...	20.13	0.7300	.0892	3.23	1.0917	.0044	.69	4.1	.0284
1903, ...	23.39	1.0440	.0888	2.49	1.5856	.0256	.72	5.3	.0214

Purification effected by the Hopedale Sewage Filters.

From the results of the yearly averages of analyses of sewage and effluent given in the preceding tables the percentages of organic matters removed in the process of filtration, as represented by the free ammonia, albuminoid ammonia and oxygen consumed, have been calculated and are presented in the following table. Tables are also appended showing, in a similar way, the purification effected in the six warmer months of the year, from June to November, inclusive, and in the six colder months, from December to May, inclusive. The results of these analyses show that the degree of purification effected by these filters during most of the time since they have been in operation is lower than has been secured from filters in other places, due, apparently, in part to the condition of the sewage as

applied to the filters and in part to the fact that the quantity of sewage applied in certain seasons of the year is far in excess of the capacity of the filters.

Purification effected by the Sewage Filters at Hopedale.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1901,	2.55	0.8085	68.3	.30	.0455	84.8	2.61	.40	84.7
1902,	2.92	0.7300	75.0	.27	.0892	67.0	3.12	.69	77.9
1903,	2.22	1.0440	53.0	.34	.0888	73.9	2.98	.72	75.8

Purification effected by the Sewage Filters at Hopedale during the Summer Months (from June to November, inclusive) of Each Year.

1901,	2.79	0.4870	88.4	.31	.0444	85.7	3.08	0.36	88.3
1902,	3.94	1.0433	73.5	.35	.1660	52.6	4.05	1.30	67.9
1903,	2.09	0.6018	71.2	.32	.0486	84.8	2.72	0.51	81.2

Purification effected by the Sewage Filters at Hopedale during the Winter Months (from December to May, inclusive) of Each Year.

1901,	2.26	1.3333	41.0	.32	.0527	83.5	1.90	0.56	70.5
1902,	2.00	0.5000	75.0	.18	.0309	82.8	2.27	0.21	90.7
1903,	2.47	1.9867	19.6	.39	.1713	56.1	3.50	1.21	65.4

Cost and Maintenance of the Works.

The cost of the works and cost of maintenance have not been ascertained.

Leicester.

Population in 1900, 3,416.

The town is situated partly in the water-shed of the Blackstone River and partly in that of the French River, the main village of Leicester being within the latter stream. The population is located chiefly in the four villages of Leicester, Cherry Valley, Greenville and Rochdale. The main village of Leicester is located in the northerly portion of the town, upon the slope of a hill, draining naturally toward the valley of Town Meadow Brook, a tributary of the French River. The village of Cherry Valley is in the water-shed of the Blackstone River in the easterly portion of the town, while the villages of Greenville and Rochdale are on the French River in the extreme southerly part of the town.

A water supply was introduced into the Leicester fire district, which includes the main village of Leicester and the village of Cherry Valley, in 1891, water being taken from wells in the neighboring town of Paxton,

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from which it is supplied by gravity. At the end of the year 1903 there were 10.77 miles of street mains in use, with which there were 320 connections. No records are kept of the quantity of water used.

Sewerage System.

The sewerage system of the town was constructed in 1894, and is available to the inhabitants of the main village of Leicester, but has not been extended to the other villages. The sewage is collected by a system of pipe sewers which convey it by gravity to a filtration area located near Town Meadow Brook, south-west of the village, where the sewage is purified by intermittent filtration after the removal of a portion of the solid matter by sedimentation, the effluent being discharged into the brook.

At the end of 1903 there were 2.14 miles of sewers in use and 70 buildings had then been connected with the system, which may be classified as follows: —

Dwelling houses,	53
Tenement houses,	7
Factories,	5
Public buildings,	4
Stables,	1
Total,	70

The population connected with the sewers at the end of 1903 is estimated to be 500.

Quantity of Sewage.

The sewage of Leicester is almost wholly domestic sewage, none of the factories in the village being connected with the sewers. All storm and surface waters are excluded from the system, and underdrains were laid beneath practically all of the sewers for the removal of ground water, in order to reduce leakage into the sewers. After a portion of the main sewer had been constructed it was found that, notwithstanding the underdrain, the leakage into it was large, and this line was taken up and replaced with iron pipe, there being no house connections along this portion of the sewer. There appears to be but little leakage into the sewers at the present time. The underdrains discharge into local water courses at convenient points.

No records of the flow of sewage are kept by the town, but several measurements have been made by the State Board of Health, the results of which are given in the following table: —

Date.	Average Flow (Gallons per Day).	Date.	Average Flow (Gallons per Day).
August 16-17, 1898,	13,600	February 3, 1903,	37,900*
April 22-23, 1902,	29,700		

* From 10 A.M. to 6 P.M.

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The results of the observations of the flow of sewage indicate that the average daily quantity is about 30,000 gallons. The following table gives the average flow of sewage per inhabitant, per mile of sewer, etc., for the year 1903: —

	Average Flow of Sewage (Gallons per Day).		Average Flow of Sewage (Gallons per Day).
Total flow,	30,000	Flow per connection,	429
Flow per inhabitant,	9	Flow per mile of sewer,	14,020
Flow per person connected with the sewer.	60		

Treatment of the Sewage before Filtration.

At the filtration area the sewage is received into settling tanks which are constructed in duplicate, each tank being 22 feet long, 7 feet wide and containing 5.7 feet in depth of sewage. The combined capacity of the tanks is about 13,000 gallons. The tanks are rectangular in shape, constructed of brick masonry and covered with a building. Sewage is usually allowed to flow into both tanks at the same time, and under ordinary conditions the sewage is ten hours in passing through the tanks, so that there is an opportunity for thorough sedimentation.

The solid matter which accumulates in the tanks is discharged upon a sludge bed having an area of about 220 square feet, which was prepared for this purpose and is underdrained by lines of tile pipe about 11 feet apart. The contents of the settling tanks are discharged upon the sludge bed about five times a year.

Description of the Filter Beds.

The area purchased by the town for sewage filtration purposes comprises about 8.7 acres of rough and uneven land on the easterly side of Town Meadow Brook, containing in some places gravelly soil, though in much of the area the soil is hard and fine. Upon this area eight filter beds have been constructed, each having an area of about 2,000 square feet, making the total area of filter beds about .36 of an acre. The soil of which the filter beds are composed was for the most part compact and hard, and the material of the entire area had to be loosened and broken up when the beds were constructed. A small amount of gravel was found upon the area, which was used in the construction of the beds. In some places rock was encountered, which was removed by blasting.

The area owned by the town includes two small knolls, the soil of one containing some gravel, while the soil in the other is very hard and compact. On both of these knolls ditches have been dug, having a slight fall from one end to the other, the aggregate length of the ditches being about 800 feet and the depth about 1 foot. Sewage is applied to these ditches

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slowly and in small quantities, and under ordinary conditions the sewage disappears without overflowing their sides. They have served for the disposal of the greater portion of the sewage in the winter season.

Underdrainage.

The filter beds are underdrained by lines of tile pipe laid 8 feet apart about 4 feet beneath the surface, the underdrainage being discharged upon the ground, whence it finds its way into Town Meadow Brook. The sludge bed, as already indicated, is underdrained by lines of tile pipe about 11 feet apart, the underdrainage in this case also being discharged upon the ground.

Method of Operating the Filters.

The usual method of operating the filter beds is to discharge all of the sewage continuously as it is received upon two of the beds for about three days, when the flow is diverted to another set of two beds. When the beds have all received a dose of sewage the ditches are put into use and the sewage is allowed to flow into each of the two ditches for three days. In this way each of the filter beds receives half of the flow of sewage for three days once in eighteen days and each ditch receives the entire flow for three days once in eighteen days. With the average flow of sewage the beds receive a dose amounting to about 700,000 gallons per acre, and the rate of filtration is about 40,000 gallons per acre per day.

Sewage is applied to the filter beds through pipes discharging at the corners of the beds. The beds are raked and cleaned about once in two weeks when free from snow and ice. In winter the beds remain level, as during the summer.

Character of the Sewage.

The sewage of Leicester, as already indicated, is strictly a domestic sewage and is quite strong.

The average character of the sewage, as shown by yearly averages of chemical analyses of monthly samples, is indicated in the following table: —

Yearly Averages of Chemical Examinations of Sewage from Leicester.

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Oxygen Consumed.	
	Total Residue.			Loss on Ignition.				Albuminoid.					
	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.	Free.	Total.	Dissolved.	Suspended.		Unfiltered.	Filtered.
1897,	77.83	63.51	14.32	44.17	33.83	10.34	2.63	.82	.49	.33	5.17	20.43	16.67
1898,	77.39	69.47	7.92	43.17	36.95	6.22	3.56	.88	.54	.34	6.18	24.30	20.56
1899,	74.70	60.23	14.47	42.10	30.35	11.75	3.54	.83	.45	.38	5.62	21.60	17.23
1900,	56.27	46.92	9.35	29.07	21.60	7.47	3.52	.67	.37	.30	4.85	12.95	10.31
1901,	31.28	25.70	5.58	16.10	12.32	3.78	3.12	.40	.28	.12	3.68	4.40	3.62
1902,	28.22	23.18	5.04	13.32	10.08	3.24	3.25	.36	.26	.10	3.41	3.21	2.55
1903,	42.17	28.16	14.01	22.05	10.32	11.73	2.67	.50	.24	.26	5.47	5.08	3.03

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Character of the Effluent.

Samples of effluent have been collected regularly for several years from the main underdrain beneath the filter beds, and the yearly averages of monthly analyses are presented in the following table. They show that the purification is not as complete as in some of the other filtration areas, due probably in part to the long storage of the sewage in the settling tank, and the method of operating the filters, but the effluent becomes further purified before reaching the stream, and has no noticeable effect upon the appearance or odor of the water in Town Meadow Brook, into which the effluent flows.

Yearly Averages of Chemical Examinations of Effluent from the Leicester Sewage Purification Works.

[Parts per 100,000.]

Year.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Free.	Albuminoid.		Nitrates.	Nitrites.			
1897,	44.04	1.5084	.2117	5.12	0.0491	.0212	6.37	11.9	.6446
1898,	43.19	1.1453	.0841	5.32	1.1783	.0187	3.80	10.1	.1689
1899,	45.53	0.8810	.0943	6.17	0.8383	.0429	4.42	8.3	.2552
1900,	34.37	0.5697	.0626	4.36	1.2279	.0475	1.29	6.7	.0991
1901,	30.99	0.5704	.0624	3.33	1.5147	.0209	1.08	5.8	.0379
1902,	20.44	1.0460	.0959	3.48	0.5845	.0524	0.97	3.1	.1618
1903,	23.67	0.7065	.0813	3.94	0.9117	.0367	0.96	4.7	.0981

Purification effected by the Leicester Sewage Filters.

From the results of the yearly averages of analyses of sewage and effluent given in the preceding tables the percentages of organic matters removed in the process of filtration, as represented by the free ammonia, albuminoid ammonia and oxygen consumed, have been calculated and are presented in the following table. Tables are also appended showing, in a similar way, the purification effected in the six warmer months of the year, from June to November, inclusive, and in the six colder months, from December to May, inclusive. The effluent is not usually affected to any material degree by dilution by ground water.

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Purification effected by the Sewage Filters at Leicester.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed	Sewage.	Effluent.	Per Cent. Removed.	Sewage	Effluent.	Per Cent. Removed.
1897,	2.63	1.5084	42.6	.82	.2117	74.2	20.43	6.37	68.8
1898,	3.56	1.1453	67.9	.88	.0841	90.4	24.30	3.80	84.3
1899,	3.54	0.8810	75.1	.83	.0943	88.6	21.60	4.42	79.5
1900,	3.52	0.5697	83.8	.67	.0626	90.7	12.95	1.29	90.0
1901,	3.12	0.5704	81.7	.40	.0624	84.4	4.40	1.08	75.2
1902,	3.25	1.0460	67.8	.36	.0959	73.4	3.21	0.97	69.8
1903,	2.67	0.7066	73.5	.50	.0813	83.8	5.08	0.96	81.1

Purification effected by the Sewage Filters at Leicester during the Summer Months (from June to November, inclusive) of Each Year.

1897,	2.96	1.7856	39.7	.97	.2580	73.4	22.94	7.54	67.1
1898,	3.78	0.8156	78.4	.87	.0584	93.3	20.62	2.59	87.4
1899,	3.81	0.4407	88.4	.95	.0583	93.9	15.29	2.08	86.4
1900,	3.86	0.2967	92.3	.75	.0475	93.7	10.37	0.89	91.4
1901,	3.71	0.4618	87.6	.44	.0573	87.0	4.82	0.75	84.4
1902,	3.67	1.1060	69.9	.37	.0926	77.7	3.42	0.86	74.8
1903,	2.96	0.6628	77.6	.50	.0596	88.1	5.47	0.88	83.9

Purification effected by the Sewage Filters at Leicester during the Winter Months (from December to May, inclusive) of Each Year.

1897,	2.90	1.4448	50.2	.77	.2059	73.3	23.81	8.82	63.0
1898,	3.06	1.6987	44.5	.86	.1222	85.8	25.98	5.78	77.8
1899,	3.06	1.2280	59.9	.67	.1253	81.3	25.25	5.06	80.0
1900,	3.33	0.9460	71.6	.63	.0840	86.7	17.93	2.47	86.2
1901,	2.49	0.7490	69.9	.37	.0730	80.3	6.30	2.11	66.5
1902,	2.55	0.8127	68.1	.34	.0868	74.4	2.98	0.96	67.8
1903,	2.25	0.7574	66.3	.46	.1042	77.3	3.98	1.20	69.8

Cost of the Works.

The cost of construction of the filter beds was $2,389, or at the rate of about $6,000 per acre. The cost was large, on account of the necessity of handling practically all of the material of which the filter beds are composed and of blasting and removing a considerable quantity of rock.

Cost of Maintenance of Filters.

The annual cost of maintenance of the filters is about $125.

Marlborough.

Population in 1900, 13,609.

The city of Marlborough is located on the divide between the water-sheds of the Sudbury and Assabet rivers, the principal part of the population being within the water-shed of the former stream and draining naturally into the Sudbury reservoir of the metropolitan water works. Nearly all of the population is contained within a small area in the central section of the city, and the outlying districts are very sparsely populated.

A public water supply was introduced in 1883 from Lake Williams, and later on was supplemented with water pumped into Lake Williams from a storage reservoir on Millham Brook, in the westerly portion of the city. At the end of 1903 there were 36.6 miles of street mains in use and 2,260 service pipes connected therewith. The average daily quantity of water used from the public works in 1903 was 570,000 gallons.

Sewerage System.

The sewerage system of the city was constructed in the years 1890 and 1891. The sewage of the greater portion of the city located within the water-shed of the Sudbury River is collected in a system of pipe sewers and conveyed by gravity to a filtration area in the easterly part of the city, in the water-shed of the Sudbury River, where it is purified by intermittent filtration after the removal of a portion of the solid matter by sedimentation. The sewage of a small low area in the neighborhood of Lake Williams, which cannot be removed by gravity by the main system, is collected at a reservoir near the water works pumping station on the northwesterly shore of Lake Williams, whence it is pumped into one of the main sewers of the city and flows thence to the filtration area by gravity.

The main sewer from the city to the filtration area is constructed of tile pipe 18 and 20 inches in diameter, and its total length is about 3½ miles. Under ordinary conditions the sewage is about two hours in passing from the city to the filtration area.

At the end of the year 1903 there were 24.2 miles of sewers in use in the city, with which 1,592 buildings were connected. The estimated population using the sewers at the end of 1903 is 10,000.

Quantity of Sewage.

The principal factories in the city of Marlborough are shoe shops, from which only very small quantities of wastes are discharged into the sewers, and the sewage is chiefly domestic sewage.

Measurements of the flow of sewage were made by the metropolitan water board for a period of about eighteen months by means of an automatic gage, which recorded continuously the height of sewage upon weirs located in the settling tanks at the filtration area, and a gage has since been main-

MARLBOROUGH.

tained at this outlet, a reading being taken of the height on the weirs at a certain hour of the day, from which the approximate daily flow has been computed. Measurements were also made by the State Board of Health in the years from 1898 to 1903, and during a portion of the years 1902–3 an automatic recording gage was maintained by the Board at this outlet. From these measurements the following table has been prepared, which gives the average daily quantity of sewage flowing during each month in the last three years and the maximum and minimum daily flow in each month: —

Flow of Sewage in Thousand Gallons per Day.

Month.	1901.			1902.			1903.		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
January,	637	1,040	340	1,109	3,240	640	1,430	2,560	980
February,	563	890	390	1,031	4,090	490	1,426	2,720	1,020
March,	1,346	3,130	440	2,364	3,240	1,190	2,028	3,300	1,450
April,	2,512	3,790	1,540	1,482	3,240	690	1,819	2,700	1,060
May,	2,000	2,990	890	740	1,250	340	786	1,210	490
June,	1,071	1,940	540	456	750	170	1,570	3,540	350
July,	529	890	240	306	1,310	200	932	1,880	640
August,	571	990	340	378	820	190	587	830	490
September,	570	890	340	275	530	40	587	827	460
October,	574	1,190	240	695	1,550	460	722	1,210	510
November,	468	890	240	642	1,020	320	610	860	490
December,	1,275	3,840	390	1,274	2,890	400	708	1,150	510
Year,	1,010	3,840	240	896	4,090	40	1,100	3,540	350

In the following table is given the average, maximum and minimum daily flow and the flow per mile of sewer, etc., in the year 1903: —

	Gallons per Day.		
	Average.	Maximum.	Minimum.
Total flow,	1,100,000	3,540,000	350,000
Flow per inhabitant,	86	277	27
Flow per person connected,	110	354	35
Flow per connection,	691	2,224	220
Flow per mile of sewer,	45,450	146,280	14,460

MARLBOROUGH.

The sewers were laid without underdrains, and much ground water entered the trenches in which the sewers were laid and the leakage into the system is very large. In addition to this leakage many cellars are connected with the sewers, so that at times of storm the flow is very greatly increased, and at times of heavy storms the main sewer becomes surcharged and sewage finds its way out through the man-holes in low places into the streets.

In the year 1903 a sewer was constructed by the metropolitan district to receive the flow of sewage in excess of the capacity of the main sewer by which the excess of flow of sewage from the Marlborough sewers is conveyed to a filtration area near the shore of the Sudbury Reservoir, where it is applied to filter beds of sand and gravel, the effluent finding its way through the ground into the reservoir.

Treatment of the Sewage before Filtration.

At the filtration area the sewage is received in two settling tanks, each of which is 25 feet 3 inches in length, 6 feet 4 inches wide and contains when full 6 feet 9 inches of sewage. In the ordinary operation of the works the sewage passes through both tanks, and with the average flow the time of passage is about twenty minutes, but at times of maximum flow the sewage passes through the tanks in about seven minutes.

The material which accumulates in the settling tanks is removed about once in two weeks, the whole contents of the tanks being discharged upon sludge beds prepared for this special purpose. These sludge beds are six in number and have a combined area of .72 of an acre. The contents of a tank are discharged upon one bed and allowed to become dry enough so that the material can be removed in carts. It is used as a fertilizer upon lands in the neighborhood. The quantity removed amounts to about 100 cubic yards in a year. The sludge discharged upon the beds has a very foul odor noticeable for a considerable distance, and when this sludge is spread upon the land for fertilizing it is also quite offensive, especially in damp weather. The sludge from one discharge of the tanks covers one of the beds to a depth of from half an inch to 4 inches when dried, and in dry weather is ready for removal in about four days, but in winter a longer time is required for the proper drying of this material.

The sewage flows from the settling tanks to the filter beds through iron screens having a 1-inch mesh, laid horizontally, and so arranged that the sewage in flowing out of the settling tanks passes upwards through the screens. The material arrested by the screens remains in the settling tanks and is removed with the sludge and discharged upon the sludge beds.

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Description of the Filter Beds.

The area purchased by the town for filtration purposes is located about three miles east of the city in the valley of a very small brook, which enters the Sudbury River at Wayland. The total area owned by the city comprises 49.4 acres of land having a gradual slope from the foot of Ward Hill in a north-easterly direction toward the brook. There is only one house within a distance of half a mile from any portion of the area, and the nearest highway is about 550 feet from the filter beds. Upon this area 24 filter beds have been constructed, 6 of which, having a combined area of .72 of an acre, are used as sludge beds, as already indicated. The remaining 18 beds have a combined area of 11.2 acres, or about .6 of an acre each. The filter beds were prepared by the removal of all of the loam and, in most cases, the subsoil, though in some of the beds a small amount of subsoil was allowed to remain. Beneath the loam and subsoil the soil of the filtration area consists of sand well adapted to filtration purposes. The sand was not disturbed except so far as was necessary in the laying of underdrains and in grading the beds.

The character of the material found in the filter beds is shown in the following table of analyses of samples of soil collected at various depths at the middle of each of the beds in 1898: —

Analyses of Filtering Material of the Marlborough Filter Beds.

Depth Beneath Surface (Feet).	Effective Size (Millimeters).			Uniformity Coefficient.			Albuminoid Ammonia (Parts per 100,000).		
	Average.	Maximum.	Minimum.	Average	Maximum.	Minimum.	Average.	Maximum.	Minimum.
Surface,	.14	.16	.12	2.9	5.8	2.3	55.5	105.7	20.2
0.25,	.15	.19	.12	2.9	6.8	2.2	39.0	83.5	14.6
0.50,	.15	.19	.12	3.1	10.2	2.3	21.0	51.1	6.9
1.00,	.14	.18	.09	2.6	3.0	2.0	10.8	29.2	5.2
2.50,	.14	.17	.11	2.6	3.0	1.9	8.9	27.8	3.3
4.00,	.14	.16	.13	2.5	2.5	2.3	7.2	12.5	2.1

Underdrainage.

The filter beds are underdrained by lines of tile pipes laid about 50 feet apart and at depths ranging from 5 to 8 feet beneath the surface. The underdrains discharge through various outlets into the small brook which flows along the north-easterly side of the area. Organic growths have at times taken place in these underdrains, obstructing their flow, and additional underdrains were provided on this account.

Method of Operating the Filters.

Sewage is applied to the filter beds generally at one point in each of the beds, in some cases the pipe discharging sewage upon the bed being located at the middle of the side of the bed and in others at the corners of the beds. Under ordinary conditions the flow of sewage is so large that there is no difficulty in flooding the beds at any time.

The ordinary method of dosing the filter beds during dry weather is to allow one bed to receive the sewage for the entire day and divert the sewage to another bed during the night, but at times of high flow two or more beds are used. By this method of application the beds receive a dose of sewage amounting to 600,000 gallons per acre in dry weather, and when the flow is diverted from a bed the surface of the sewage is frequently near the top of the embankments, and the bed is flooded to a depth of more than a foot. This method of dosing results in the imperfect purification of the sewage, and the surfaces of the beds quickly become clogged. The beds are somewhat uneven, and the higher portions receive a considerably less quantity of sewage than the lower portions. The quantity of sewage in dry weather amounts to 50,000 gallons per acre of filter beds, and during such times all of the sewage is applied to the filters, and the purification, notwithstanding the faulty method of application, is quite thorough.

During times of extremely high flow the quantity of sewage received at the area amounts to as much as 200,000 gallons per acre per day, and at such times a large portion of the sewage is discharged directly into the brook without any attempt at purification, and at times in the spring practically all of the sewage is disposed of in this way for a considerable time.

Very few observations of the temperature of this sewage have been recorded, but such as have been made show that the temperature of the sewage is affected considerably by the surface water which enters the sewers. The winter temperature is generally about 41° F., but sometimes falls to considerably below this point.

After a bed has been used for about five weeks in summer it is raked and harrowed and allowed to rest, sometimes for a period of two months. The beds are ploughed and ridged in the fall to prepare them for winter use, and in the spring are allowed to dry when the solid matter is removed by raking. From 12 to 16 cubic yards of sludge have been removed from a single bed at these times. After raking, the beds are again ploughed and levelled for use in the summer.

Crops are not grown upon these filters, and such use would be impracticable on account of the excessive quantity of sewage which is necessarily applied to them at times of high flow in the sewers.

MARLBOROUGH.

Character of the Sewage.

Owing to the great leakage into the sewers and the large quantity of storm water which finds its way into them the sewage varies greatly in strength from time to time. At times of low flow the sewage is very strong, but in the spring, when the leakage is great, the sewage is weak. The solid matter becomes considerably broken up in the passage of the sewage through the main sewer and settling tanks, and is in a very finely divided state under ordinary conditions when discharged upon the filter beds, but its odor is not especially offensive.

The average character of the sewage is shown by the following table of yearly averages of monthly samples of the sewage: —

Yearly Averages of Chemical Examinations of Sewage from Marlborough.

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Oxygen Consumed.	
	Total Residue.			Loss on Ignition.			Free.	Albuminoid.				Unfiltered.	Filtered.
	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.		Total.	Dis-solved.	Sus-pended.			
1892,	56.02	35.74	20.28	24.10	11.11	12.90	2.19	0.58	.26	.32	6.87	-	-
1893,	72.36	34.93	37.43	37.27	10.84	26.43	2.01	0.61	.22	.39	7.36	-	-
1894,	61.11	35.34	25.77	29.56	9.43	20.13	3.25	0.76	.27	.49	6.68	5.01	2.40
1895,	42.54	28.19	14.35	17.73	7.80	9.93	1.94	0.40	.15	.25	5.25	4.75	1.70
1896,	43.41	28.48	14.93	21.19	9.61	11.58	2.11	0.43	.20	.23	5.05	4.03	2.23
1897,	51.90	32.69	19.21	25.88	10.25	15.63	2.39	0.67	.32	.35	6.34	4.68	2.29
1898,	33.23	24.46	8.77	13.32	6.49	6.83	1.99	0.46	.22	.24	4.91	2.59	1.36
1899,	51.99	34.13	17.86	27.62	12.37	15.25	4.01	0.81	.39	.42	6.07	5.88	3.07
1900,	71.30	38.38	32.92	39.45	14.53	24.92	4.42	1.17	.43	.74	7.05	8.33	3.81
1901,	47.53	33.72	13.81	23.97	12.93	11.04	3.73	0.75	.34	.41	6.53	4.62	2.78
1902,	50.68	35.93	14.75	23.57	12.25	11.32	3.90	0.72	.34	.38	8.26	5.63	3.69
1903,	44.82	31.07	13.75	21.80	10.32	11.57	3.15	0.54	.27	.27	5.90	4.44	2.50

Character of the Effluent.

The effluent from the Marlborough sewage filters is ordinarily well purified, notwithstanding the excessive quantity of sewage that is sometimes applied to the filter beds.

The yearly averages of monthly samples of effluent collected from two of the underdrains are presented in the following table: —

MARLBOROUGH.

Yearly Averages of Chemical Examinations of the Effluent from the Marlborough Sewage Purification Works.

[Parts per 100,000.]

Year.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Free.	Albuminoid.		Nitrates.	Nitrites.			
1892,	26.36	0.1986	.0141	4.95	0.8003	.0318	-	6.7	-
1893,	28.92	0.5931	.0353	5.08	1.0130	.0234	-	7.7	.0404
1894,	32.18	0.4983	.0375	5.69	1.1281	.0159	.36	8.2	.0399
1895,	29.70	0.6427	.0299	5.54	0.9056	.0120	.34	7.8	.0883
1896,	27.96	0.6236	.0416	5.54	0.6885	.0096	.40	7.4	.1787
1897,	28.19	0.7613	.0443	6.17	0.5242	.0151	.41	7.3	.1226
1898,	24.80	0.6208	.0328	5.00	0.5441	.0171	.34	6.8	.1234
1899,	31.21	0.8502	.0480	5.61	0.9009	.0224	.51	7.3	.0682
1900,	32.92	0.8002	.0528	5.90	1.1927	.0316	.58	6.6	.0963
1901,	28.81	0.9004	.0582	5.54	0.7865	.0194	.56	6.8	.0868
1902,	28.83	1.0004	.0490	5.55	1.1198	.0210	.51	7.0	.0662
1903,	27.05	1.2365	.0622	5.97	0.3521	.0272	.73	6.3	.3016

Purification effected by the Marlborough Sewage Filters.

From the yearly averages of sewage and effluent given in the preceding tables the percentages of organic matters removed, as represented by the free ammonia, albuminoid ammonia and oxygen consumed, have been calculated and are presented in the following table. Tables are also appended showing, in a similar way, the purification effected in the six warmer months of the year, from June to November, inclusive, and in the six colder months, from December to May, inclusive. A table is also appended showing the purification effected by the Marlborough filters, using calculated analyses of the effluent instead of the actual analyses, in order to make allowance for admixture of ground water, a considerable quantity of which enters the underdrains.

Purification effected by the Sewage Filters at Marlborough.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1892,	2.19	0.1986	90.9	0.58	.0141	97.6	-	-	-
1893,	2.01	0.5931	70.6	0.61	.0353	94.2	-	-	-
1894,	3.25	0.4983	84.7	0.76	.0375	95.1	5.01	.36	92.9
1895,	1.94	0.6427	66.8	0.40	.0299	92.6	4.75	.34	92.8
1896,	2.11	0.6236	70.4	0.43	.0416	90.3	4.03	.40	90.1
1897,	2.39	0.7613	68.2	0.67	.0443	93.4	4.68	.41	91.2
1898,	1.99	0.6203	68.8	0.46	.0328	92.9	2.59	.34	86.9
1899,	4.01	0.8502	78.8	0.81	.0480	94.1	5.88	.51	91.3
1900,	4.42	0.8002	81.9	1.17	.0528	95.5	8.33	.58	93.0
1901,	3.73	0.9004	75.9	0.75	.0582	92.2	4.62	.56	87.9
1902,	3.90	1.0004	74.3	0.72	.0490	93.2	5.63	.51	90.9
1903,	3.15	1.2365	60.7	0.54	.0622	88.5	4.44	.73	83.6

MARLBOROUGH.

Purification effected by the Sewage Filters at Marlborough during the Summer Months (from June to November, inclusive) of Each Year.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1900,	5.38	0.7202	86.6	1.55	.0465	97.0	10.02	.47	95.3
1901,	4.82	0.7363	84.7	0.94	.0534	94.3	5.40	.51	90.6
1902,	5.18	0.9758	81.2	0.95	.0428	95.5	6.73	.35	94.8
1903,	3.34	1.4753	55.8	0.46	.0582	87.3	4.52	.77	83.0

Purification effected by the Sewage Filters at Marlborough during the Winter Months (from December to May, inclusive) of Each Year.

Year.	Free Ammonia. Sewage.	Free Ammonia. Effluent.	Free Ammonia. Per Cent. Removed.	Total Albuminoid Ammonia. Sewage.	Total Albuminoid Ammonia. Effluent.	Total Albuminoid Ammonia. Per Cent. Removed.	Oxygen Consumed. Sewage.	Oxygen Consumed. Effluent.	Oxygen Consumed. Per Cent. Removed.
1900,	3.61	1.0123	72.0	0.85	.0721	91.5	7.10	.74	89.6
1901,	2.89	0.9930	65.6	0.59	.0607	89.7	3.70	.58	84.3
1902,	2.22	1.0808	51.3	0.45	.0506	88.8	4.50	.57	87.3
1903,	3.11	0.7727	75.2	0.65	.0576	91.1	4.43	.68	84.7

Purification effected by the Sewage Filters at Marlborough, as indicated by the Calculated Analyses of the Effluent.

Year.	Free Ammonia. Sewage.	Free Ammonia. Effluent.	Free Ammonia. Per Cent. Removed.	Total Albuminoid Ammonia. Sewage.	Total Albuminoid Ammonia. Effluent.	Total Albuminoid Ammonia. Per Cent. Removed.	Oxygen Consumed. Sewage.	Oxygen Consumed. Effluent.	Oxygen Consumed. Per Cent. Removed.
1899,	4.01	0.9241	77.0	0.81	.0521	93.6	5.88	.55	90.6
1900,	4.42	0.9641	78.2	1.17	.0636	94.6	8.33	.70	91.6
1901,	3.73	1.0681	71.4	0.75	.0690	90.8	4.62	.66	85.7
1902,	3.90	1.5089	61.3	0.72	.0739	89.7	5.63	.77	86.3
1903,	3.15	1.2365	60.7	0.54	.0622	88.5	4.44	.73	83.6

The brook which receives the effluent from the Marlborough filters has a water-shed, at the filtration area, of about .9 of a square mile, and at its mouth, where it joins the Sudbury River in Wayland, 22.7 square miles. This brook at times of low flow, when all of the sewage is being purified, is not unfavorably affected in appearance or odor by the sewage effluent, but it is very badly polluted at times by the discharge of unpurified sewage. The effect of this discharge, however, is generally not noticeable near the mouth of the stream, which flows with a sluggish current through a sparsely settled territory.

Cost of the Works.

When the sewage purification works were first constructed 13 filter beds, with an area of 7.5 acres, were prepared for the disposal of sewage, and 6

beds, with an area of .72 of an acre, for the disposal of sludge. The cost of these original filter beds, together with the settling tanks and the brick building over them, was $24,200, or $2,951 per acre. The remaining 5 beds, having an aggregate area of 3 acres, were constructed subsequently, and cost $7,317, or $2,067 per acre. The total cost of the purification works to date is as follows: —

Land (49.4 acres),	$3,000
Filter beds (11.92 acres), including sludge beds, settling tanks and building over tanks,	31,517
Total,	$34,517

Maintenance of the Filters.

The annual cost of maintenance is shown by the following table: —

1893,	$497 19	1899,	$1,095 72
1894,	606 04	1900,	1,058 64
1895,	584 85	1901,	1,052 34
1896,	768 67	1902,	950 45
1897,	1,252 15	1903,	1,042 67
1898,	1,106 51		

NATICK.

Population in 1900, 9,488.

The town of Natick is situated within the water-shed of the Charles and Sudbury rivers. The population is located principally in two villages. The chief village (Natick), containing about two-thirds of the population of the town, is situated in the water-shed of Lake Cochituate, a tributary of the Sudbury River used as a source of water supply by the metropolitan water district. The village of South Natick is located on the Charles River.

A public water supply was introduced in 1874 from Dug Pond, a tributary of Lake Cochituate, and is supplied to both villages, but, owing to the objectionable quality of the water, it was abandoned in 1902, and water has since been taken from a large well situated near Lake Cochituate, northwest of the main village. Water is supplied to both of the principal villages, and at the end of 1903 there were 42.12 miles of distributing pipe in use, with which there were 1,892 connections. The average daily consumption of water in the year 1903 was 492,000 gallons.

Sewerage System.

The sewerage system of Natick was constructed in 1895–96 and is available to the inhabitants of the main village, but the system has not been extended to include South Natick, which lies at a lower level. The sewage

NATICK.

is collected in a system of pipe sewers and conveyed to a reservoir and pumping station near the southerly end of Lake Cochituate, from which it is pumped to a filtration area in the north-westerly portion of the town of Natick, adjacent to the filtration area of the town of Framingham, where the sewage is purified by intermittent filtration and the effluent discharged into Bannister Brook.

The total length of sewers constructed to the end of the year 1903 was about 10.81 miles, and 634 buildings had been connected with the sewers at that time, which may be roughly classified as follows: —

Dwelling houses,	583
Business blocks,	35
Factories,	6
Schoolhouses,	5
Hotels,	1
Churches,	4
Total,	634

The estimated population contributing sewage at the end of the year 1903 was 4,000.

Quantity of Sewage.

The quantity of sewage pumped to the filtration area, as shown by the pumping records in the years since the works have been in operation, is given in the following table.

Quantity of Sewage pumped, in Thousand Gallons per Day.

Month.	1898.			1899.			1900.		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
January,	448	652	141	797	1,057	495	258	444	157
February,	637	1,037	334	609	988	422	553	1,090	248
March,	668	817	453	1,072	1,425	657	800	1,530	627
April,	565	1,030	173	839	1,163	459	599	787	353
May,	567	950	143	450	699	311	597	765	247
June,	435	827	310	289	387	213	436	657	216
July,	291	436	203	229	312	167	294	497	131
August,	405	680	241	161	287	110	222	275	180
September,	308	471	106	170	192	143	168	338	111
October,	341	683	173	167	402	117	199	338	123
November,	651	946	364	211	306	122	301	692	141
December,	726	1,562	439	192	249	134	629	1,115	235
Year,	503	1,562	106	432	1,425	110	421	1,530	111

NATICK.

Quantity of Sewage pumped, in Thousand Gallons per Day — Concluded.

MONTH.	1901.			1902.			1903.		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
January,	400	661	157	906	1,615	682	765	1,108	577
February,	294	423	246	628	994	276	644	885	438
March,	618	1,266	123	1,482	2,213	1,010	1,119	1,792	681
April,	1,469	2,242	974	971	1,519	496	1,115	1,740	688
May,	1,225	1,697	862	504	774	237	502	707	209
June,	758	1,413	389	361	654	247	553	1,211	261
July,	440	601	314	238	372	171	469	708	188
August,	410	691	244	209	327	159	327	553	246
September,	395	633	269	225	380	126	282	380	180
October,	379	567	262	248	412	192	338	642	144
November,	332	579	161	263	499	207	333	567	290
December,	847	1,949	349	627	1,501	226	347	610	202
Year,	631	2,242	123	555	2,213	126	566	1,792	144

The following table gives the average, maximum and minimum flow per inhabitant, per person connected with the sewers, etc., during the year 1903 :—

	FLOW OF SEWAGE (GALLONS PER DAY).		
	Average.	Maximum.	Minimum.
Total flow,	566,000	1,792,000	144,000
Flow per inhabitant,	58	181	15
Flow per person connected with the sewers,	142	448	36
Flow per connection,	893	2,826	227
Flow per mile of sewer,	52,400	165,800	13,300

There are no unusually large contributors of sewage in Natick, the principal large contributors being shoe factories, none of which produce large quantities of manufacturing wastes. There are no very foul manufacturing wastes discharged into the sewers from any source, and the principal variations in the character of the sewage are those due to dilution.

The sewers were constructed on the separate plan, surface water being excluded, but the variations in the flow, as shown by the tables, are large, and are due chiefly to leakage of ground water into the sewers. The soil upon which the town is built is coarse and porous, and in many places the sewers were laid below the level of the ground water. No underdrains were laid beneath the sewers, and the leakage into the sewers at some places is enormous. The leakage has been further increased by the house connections made from time to time, many of which are also below the level of the ground water. There are no connections through which surface water is admitted to the sewers, and the great variations in flow, ranging from a minimum of 144,000 gallons per day in dry weather to a maximum of 1,792,000 gallons per day in the spring, are due almost wholly to leakage of ground water into the sewers.

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The portion of the town in which sewers have been constructed is within the water-shed of Lake Cochituate, and the main sewer between the town and the pumping station passes near the southerly shore of the lake. In order to prevent danger of the escape of sewage, this portion of the sewer was constructed of cast-iron pipe with lead joints.

Treatment of the Sewage before Filtration.

The sewage, before entering the reservoir at the pumping station, passes through a screen of iron bars spaced three-quarters of an inch apart. The screen is 5.5 feet long and 4 feet wide, and so arranged that when it is cleaned the sewage is only a few inches deep in front of it, but as the screen becomes clogged, the sewage rises, and finally, unless the clogging is removed, flows over the top of the screen. The screen is cleaned daily, the quantity of material removed amounting to about one pailful in two weeks, which is burned beneath the boilers.

After passing the screens the sewage enters covered masonry reservoirs three in number, each 110 feet long and 29 feet wide and arranged to hold a maximum depth of 8.55 feet of sewage. Their combined capacity is 500,000 gallons. No provision is made at the reservoir and pumping station for the removal of solid matter from the sewage, and the entire contents of the tanks are pumped each day to the filtration area. About once a year it is necessary to clean the bottom of the reservoir, and at such times it is found that solid matter has collected to a depth of about 6 inches. This matter is removed by mixing it with the sewage and pumping it to the filter beds.

The pumping plant consists of two pumps, one of which has a capacity of 1,000,000 gallons per day and the other a capacity of 2,000,000 gallons per day. The valves of the pumps are ordinary water valves, and some trouble has been experienced by solid matters getting beneath them. The pumps are ordinarily operated during the daytime and the night flow of sewage is stored in the reservoir, but at times of very high flow in the winter and spring the quantity of sewage is sometimes so great that it is necessary to operate the pumps almost continuously during the twenty-four hours.

All of the sewage received at the reservoirs and pumping station is pumped to the filtration area, and no sewage is allowed to escape into the lake or adjacent streams.

The force main from the pumping station to the filtration area consists of cast-iron pipe 16 inches in diameter and 7,861 feet in length. It is so arranged that all of the sewage contained in the pipe at the time the pumps are stopped remains there until pumping is resumed the next day, the quantity of sewage held in the pipe in this way amounting to about 82,000 gallons.

The character of the sewage discharged at the filtration area varies considerably during the day. The sewage remaining in the force main over night consists of heavy sewage pumped from the bottom of the reservoir

NATICK.

on the preceding day which contains much solid matter, and when the pumps are started in the morning a considerable additional quantity of heavy sewage is taken into the force main. After this matter has reached the area the sewage received subsequently contains much less solid matter until toward the end of the day's pumping, when the solid matter collecting in the reservoir flows toward the pump well, as the depth of sewage in the reservoir becomes small. No attempt is made to keep the heavy sewage separate from the other sewage at the filtration area, and all of the sewage is discharged directly upon the filter beds.

Description of the Filter Beds.

The filtration area is located about two miles north-west of the village of Natick, on the southerly side of the Boston and Worcester turnpike, adjacent to the Framingham filtration area, which is on the northerly side of that highway. There is no population in the immediate vicinity of the Natick filtration area, the nearest house being 1,200 feet distant, and there are not more than six houses within half a mile.

The area controlled by the town for sewage-disposal purposes is 97.5 acres, much of which is nearly a level plain, originally covered with wood, but containing a finer soil than the Framingham area, a considerable portion of the land being wet and swampy. Drainage from this area flows naturally toward Bannister Brook, which receives the effluent from the Framingham area.

Upon this tract 11 filter beds have been constructed, having an aggregate area of 11.1 acres, 10 of the beds having an area of a little over .9 of an acre each, and the remaining bed 1.9 acres. The filter beds were prepared by removing the trees and stumps and the surface soil and subsoil, which was used in forming embankments between the beds.

The average character of the filtering material in the 6 beds first constructed, as shown by samples of the soil taken at various depths from the middle of each of the beds, is shown in the following table: —

Analyses of Filtering Material of the Natick Filter Beds.

Depth Below Surface (Feet).	Effective Size (Millimeters).			Uniformity Coefficient.			Albuminoid Ammonia (Parts per 100,000).		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
Surface,	.15	.29	.04	7.0	15.8	2.4	18.2	33.7	7.0
0.25,	.13	.26	.04	6.6	12.6	2.5	13.3	21.3	3.6
0.50,	.13	.26	.04	6.9	15.1	2.3	12.0	18.1	3.8
1.00,	.15	.28	.04	5.3	11.0	1.8	7.0	14.4	1.4
2.50,	.18	.25	.09	3.3	5.6	1.9	4.1	11.0	1.0

The results show that the filtering material is of good quality, though in some cases it is quite fine.

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Underdrainage.

The beds are underdrained by lines of tile pipe placed 36 feet apart at a depth of about 6 feet beneath the surface. All the underdrains discharge into one main underdrain, which conveys the effluent to Bannister Brook above the point where the effluent from the Framingham filtration area is discharged into that stream.

Method of Operating the Filters.

Sewage is applied to the filter beds through pipes leading from manholes at each corner of each bed. During the summer months each bed receives some sewage every day, but during the winter two beds receive the whole flow of sewage, generally for two days at a time. With the ordinary dry weather flow of sewage the beds receive sewage at the rate of 30,000 gallons per acre per day. During periods of high flow the average rate is 170,000 gallons per day, and the day's flow to a single bed in winter may at times amount to more than 800,000 gallons per day. The result of applying an excessive quantity of sewage to the beds, as is necessary at times of high flow, is to keep them flooded for long periods during wet weather, especially in the winter and spring, and, in consequence, the sewage is imperfectly purified at such times. At times of high flow a portion of the sewage has been discharged directly into the swamp adjoining Bannister Brook without purification.

In summer the beds are planted with corn, and all the care which they receive is that which is necessary to prepare them for planting in the spring and to care for the corn during the summer months. After the corn has been cut off in the fall nothing further is done to the surfaces of the beds until spring. Ice collects upon the filters during the winter, resting upon the tops of the corn hills, and under ordinary circumstances, when the flow is not excessive, the sewage passes beneath the ice in the hollows between the hills.

The average temperature of the sewage applied to the beds is high in the winter months, partly on account of the leakage of ground water into the sewers, and also, in recent years, on account of the fact that the water supply of the town is drawn from the ground. Observations of the temperature of the sewage in very cold weather in the winter show that as it arrives at the filter beds it is about 46° F. The temperature of the effluent is about 40° F.

Character of the Sewage.

The sewage of Natick varies considerably in strength in different seasons of the year, owing to the leakage of ground water into the sewers. On the average it is a fairly weak sewage and contains very little manufacturing waste.

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The average character of the sewage in the years since the works were constructed is shown by the following table, giving the yearly averages of monthly analyses: —

Yearly Averages of Chemical Examinations of Sewage from Natick.

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Oxygen Consumed.	
	Total Residue.			Loss on Ignition.			Free.	Albuminoid.					
	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.		Total.	Dis-solved.	Sus-pended.		Unfiltered.	Filtered.
1897,	26.99	24.75	2.24	8.14	6.95	1.19	0.59	.16	.10	.06	3.93	1.21	0.90
1898,	26.12	23.67	2.45	7.07	5.96	1.11	0.78	.19	.10	.09	4.25	1.19	0.78
1899,	34.94	29.72	5.22	13.42	9.05	4.37	1.52	.31	.19	.12	5.70	2.93	2.12
1900,	35.77	27.06	8.71	13.86	7.37	6.49	1.48	.38	.17	.21	5.15	3.26	2.02
1901,	33.27	24.32	8.95	14.01	7.32	6.69	1.24	.33	.15	.18	4.45	2.09	1.37
1902,	31.02	26.02	5.00	12.83	9.25	3.58	1.60	.28	.17	.11	4.63	3.05	2.12
1903,	36.13	30.58	5.55	13.65	9.09	4.56	1.48	.32	.17	.15	5.95	3.27	2.25

Character of the Effluent.

The effluent of the Natick filter beds is discharged through a single underdrain into Beaver Dam Brook, above the outlet of the Framingham underdrains. The effluent is diluted considerably by ground water and the results of monthly analyses show that it is quite well purified.

The yearly averages of monthly analyses of the effluent collected from the main underdrain are shown in the following table: —

Yearly Averages of Chemical Examinations of Effluent from the Natick Sewage Purification Works.

[Parts per 100,000.]

Year.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Free.	Albuminoid.		Nitrates.	Nitrites.			
1897,	19.68	.0329	.0134	3.46	.4450	.0092	.28	6.5	.0042
1898,	20.55	.0789	.0139	3.42	.5193	.0063	.24	6.1	.0057
1899,	25.59	.1259	.0532	4.45	.8500	.0059	.31	6.7	.0055
1900,	23.23	.1403	.0242	4.40	.5862	.0057	.29	6.0	.0132
1901,	20.42	.2361	.0257	3.86	.3196	.0095	.28	6.0	.0297
1902,	22.46	.3566	.0314	4.04	.4697	.0166	.36	6.0	.1300
1903,	20.62	.6150	.0319	4.04	.2217	.0195	.44	5.8	.2290

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Purification effected by the Natick Sewage Filters.

From the results of the yearly averages of the analyses of sewage and effluent given in the preceding tables the percentages of organic matters removed in the process of filtration, as represented by the free ammonia, albuminoid ammonia and oxygen consumed, have been calculated and are presented in the following table. Tables are also appended showing, in a similar way, the purification effected in the six warmer months of the year, from June to November, inclusive, and in the six colder months, from December to May, inclusive. A table is also appended showing the purification effected after making allowance for ground water which finds its way into the underdrain. In making this calculation it has been assumed that the chlorine of the ground water which finds its way into the underdrain is normal, and that if there were no such leakage the chlorine in the effluent would be the same as that in the sewage.

Purification effected by the Sewage Filters at Natick.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1897, ...	0.59	.0329	94.4	.16	.0134	91.6	1.21	.28	76.9
1898, ...	0.78	.0789	89.9	.19	.0139	92.7	1.19	.24	79.8
1899, ...	1.52	.1259	91.7	.31	.0532	82.8	2.93	.31	89.4
1900, ...	1.48	.1403	90.5	.38	.0242	93.6	3.26	.29	91.1
1901, ...	1.24	.2361	81.0	.33	.0257	92.2	2.09	.28	86.6
1902, ...	1.60	.3566	77.7	.28	.0314	88.8	3.05	.36	88.2
1903, ...	1.48	.6150	58.4	.32	.0319	90.0	3.27	.44	86.5

Purification effected by the Sewage Filters at Natick during the Summer Months (from June to November, inclusive) of Each Year.

1897, ...	0.86	.0504	94.1	.22	.0164	92.5	1.90	.27	85.8
1898, ...	0.93	.0949	89.8	.22	.0184	91.6	1.60	.33	79.4
1899, ...	2.24	.1330	94.1	.41	.0823	79.9	4.32	.38	91.2
1900, ...	1.95	.0568	97.1	.53	.0217	95.9	3.95	.26	93.4
1901, ...	1.27	.1978	84.4	.42	.0233	94.5	2.22	.26	88.3
1902, ...	2.24	.3659	83.7	.37	.0317	91.4	3.58	.36	89.9
1903, ...	1.95	.8020	58.9	.36	.0320	91.1	3.50	.46	86.9

NATICK.

Purification effected by the Sewage Filters at Natick during the Winter Months (from December to May, inclusive) of Each Year.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1897, ...	0.27	.0154	94.8	.06	.0082	86.3	0.62	.19	69.4
1898, ...	0.67	.0556	91.7	.21	.0118	94.4	0.78	.27	65.4
1899, ...	0.51	.0627	87.7	.16	.0090	94.4	0.96	.14	85.4
1900, ...	1.22	.2824	76.9	.26	.0418	84.1	2.89	.40	86.2
1901, ...	1.21	.2123	82.5	.22	.0231	89.5	2.12	.25	88.2
1902, ...	1.00	.3617	63.8	.18	.0315	82.5	2.27	.34	85.0
1903, ...	0.82	.3497	57.4	.26	.0278	89.3	2.95	.43	85.4

Purification effected by the Sewage Filters at Natick, as indicated by the Calculated Analyses of the Effluent.

1900, ...	1.48	.1656	88.8	.38	.0286	92.5	3.26	.34	89.6
1901, ...	1.24	.2745	77.9	.33	.0299	90.9	2.09	.33	84.2
1902, ...	1.60	.4118	74.3	.28	.0363	87.0	3.05	.42	86.2
1903, ...	1.48	.9248	37.5	.32	.0480	85.0	3.27	.66	79.8

Cost of the Works.

The cost of construction of the purification works of the town of Natick, so far as it has been ascertained from printed reports, is given in the following table: —

Reservoir, ...	$44,000 00
Pumping station, ...	11,500 00
Pumping machinery, ...	5,800 00
Land for filter beds (97.5 acres), ...	2,200 00
Construction of filter beds (11.1 acres), ...	23,500 00
Total, ...	$87,000 00

Cost of Maintenance of the Filters.

The cost of maintenance of the filtration area is about $125 a year. In the year 1903 a crop of corn raised upon the area was sold for $96.

NATICK.

The annual cost of maintenance of the pumping station, including fuel, labor and repairs, is as follows: —

1902,	$2,453 83
1903,	2,574 00

PITTSFIELD.

Population in 1900, 21,766.

The city of Pittsfield is situated in the water-shed of the Housatonic River. The population is located principally in the valleys of the east and west branches of this stream, just above their junction.

A public water supply was introduced into the city in 1855, and water is at present taken from several mountain streams, from which it is supplied by gravity. At the end of the year 1903 there were 66.4 miles of distributing mains in use, with which there were about 4,000 connections. No records are kept of the quantity of water used.

Sewerage System.

The sewage of the city at the present time is collected by a system of pipe sewers into two main sewers constructed of brick, known respectively as the east and west trunk sewers, one following the valley of the east branch and the other that of the west branch of the Housatonic River, which convey the sewage to a pumping station situated near the junction of these branches, whence the sewage is pumped to a filtration area in the southern portion of the city, where it is purified by intermittent filtration, the effluent being discharged into the Housatonic River.

The system has been built chiefly since 1890, and has been constructed on the separate plan, but previous to 1890 many sewers and drains had been constructed to remove both sewage and surface water, some of which are still in use. For the most part the old sewers are used as storm-water drains, but much sewage finds its way into them, and at the present time a quantity of somewhat dilute sewage, amounting to about 600,000 gallons per day, is discharged from a system of drains into the west branch of the Housatonic River, near West Housatonic Street.

The total length of sewers constructed at the end of the year 1903 was 31.7 miles, and there were at that time 1,827 buildings connected with the sewers. The total population contributing sewage at the end of 1903 was estimated to be about 15,000.

Quantity of Sewage.

Purification works were constructed in 1901 and completed in 1902, and records of the quantity of sewage pumped have been kept throughout the year 1903. A summary of these records is presented in the following table: —

PITTSFIELD.

Quantity of Sewage pumped.

Month.	Gallons per Day.		
	Average.	Maximum.	Minimum.
January,	1,268,000	1,650,000	581,000
February,	1,443,000	2,761,000	1,018,000
March,	1,406,000	1,617,000	949,000
April,	1,463,000	1,596,000	1,004,000
May,	1,419,000	1,671,000	886,000
June,	1,541,000	2,131,000	1,087,000
July,	1,426,000	1,821,000	1,084,000
August,	1,483,000	1,702,000	1,185,000
September,	1,561,000	1,692,000	1,178,000
October,	1,501,000	1,688,000	1,154,000
November,	1,488,000	1,767,000	1,126,000
December,	1,479,000	1,757,000	902,000
Year,	1,456,000	2,761,000	581,000

The following table gives the average, maximum and minimum flow per inhabitant, per person connected with the sewers, etc., during the year 1903: —

	Gallons per Day.		
	Average.	Maximum.	Minimum.
Total flow,	1,456,000	2,761,000	581,000
Flow per inhabitant,	65	122	26
Flow per person connected with the sewers,	97	184	39
Flow per connection,	797	1,511	318
Flow per mile of sewer,	45,930	87,090	18,330

In some sections of the city the sewers are laid in soil containing a large quantity of water, and there is a very large leakage into the sewers in these places at certain seasons of the year. In one section, where the main sewer passes near a pond, the sewer is built of cast-iron pipe with lead joints, in order to exclude ground water.

Several manufacturing establishments are connected with the sewers, the most important of which is a woolen mill from which large quantities of wool-scouring waste are discharged into the sewers.

Treatment of the Sewage before Filtration.

The sewage, before entering the reservoir at the pumping station, discharges into a screen chamber in which there are two sets of screens, one in front of the other. The first screen through which the sewage passes is built of iron rods, with open spaces between them of 1 inch. The area of this screen is about 30 square feet, and it is so arranged that this area is available at all times. The second screen is of the same area and consists of iron rods with open spaces between them of three-quarters of an inch.

PITTSFIELD.

The screens are cleaned by means of rakes, the quantity of screenings removed being about two wheel-barrow loads each day.

From the screen chamber the sewage passes into three covered masonry reservoirs, having a combined capacity of 1,500,000 gallons, designed to store the flow of sewage at night, so that the pumps need be operated only during the day. Each reservoir is 200 feet in length and 30 feet in width, and the maximum depth of sewage provided for is 14 feet. The reservoirs are not designed to intercept any of the solid matter in the sewage, but are so arranged that as much as possible of the solid matter which settles to the bottoms of the reservoirs will pass to the pumps each day as the reservoirs are emptied. It has not been necessary to clean the reservoirs as yet, and inspection shows that very little solid matter has accumulated in their bottoms.

The pumping plant consists of one horizontal triplex power pump driven by an electric motor, the power being supplied by an electric light company. The pump has a nominal capacity of 5,000,000 gallons per day, and the pumping station has been arranged so that another set of machinery may be introduced when it becomes necessary. Some trouble was experienced in the beginning with the electric motor by which the pump was operated, and it was occasionally necessary to discharge sewage into the river while repairs were being made in the machinery. During the past year, however, the pumping plant appears to have operated satisfactorily.

The force main from the pumping station to the filtration area is constructed of cast-iron pipe 24 inches in diameter and 11,476 feet in length, the difference in elevation between the storage reservoirs and the filtration area being about 40 feet. The line of the force main follows approximately the contour of the surface of the ground, and at low points blow-offs are provided so that the pipe can be emptied when necessary. After the pumps are stopped at night much of the sewage in the force main remains there until pumping is resumed, and the quantity of sewage held in the force main in this way is about 270,000 gallons. When the pumps are operated at their normal rate the velocity through the force main is about 2.4 feet per second.

The sewage remaining in the force main over night is somewhat stronger than the average, and the first sewage drawn from the reservoir in the morning is also strong, due to the accumulation of solid matter in the pump well during the night. After the sewage remaining in the force main has been discharged and the heavy sewage collecting in the pump well over night has been delivered at the filter beds the sewage becomes much weaker, until toward the end of the pumping, when the solid matter toward the bottom of the reservoir is again drawn into the force main.

PITTSFIELD.

Description of the Filter Beds.

The area purchased by the city for sewage-disposal purposes comprises about 100 acres, which was originally a nearly level sandy plain adjoining the Housatonic River just above the boundary line between Pittsfield and Lenox. The area is bordered on the east by the Housatonic River and on the west by the New York, New Haven & Hartford railroad, and its general elevation is perhaps 30 feet above the level of the river, which flows at the foot of a steep bluff. The nearest dwelling house is half a mile from the filter beds and there are very few houses within a mile.

Upon this area 29 filter beds have been constructed, having a combined area of 24.78 acres, the actual area of the filter bed surfaces, exclusive of the embankments, being 21.67 acres. The filter beds were prepared by removing the soil and subsoil from the surface of the ground, this material being used in making the embankments.

The following table gives the average results of analyses of samples of sand collected from the middle of each of the filter beds at various depths: —

Analyses of Filtering Material of the Pittsfield Filter Beds.

Depth Beneath Surface (Feet).	Effective Size (Millimeters).			Uniformity Coefficient.			Albuminoid Ammonia (Parts per 100,000).		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
Surface,	.15	.26	.04	3.7	5.9	2.0	17.86	42.10	4.83
0.25,	.15	.27	.03	3.6	7.2	1.9	6.29	18.02	1.02
0.50,	.16	.33	.05	3.5	6.8	1.8	4.58	11.67	1.29
1.00,	.16	.29	.08	2.9	6.1	1.8	2.69	5.75	1.01
2.00,	.18	.29	.12	3.1	8.6	1.9	1.53	3.08	0.75

A considerable portion of the land not yet used for filtration purposes contains coarser soil than that found in some of the filter beds.

Underdrainage.

The filter beds are arranged approximately in five rows extending from the railroad to the river, and through the centre of each row is a line of main underdrain discharging at the edge of the steep bluff bordering the river. Connected with each of the main underdrains there are lines of 3-inch lateral drains about 35 feet apart in each of the filter beds and about 4 feet beneath the surface.

Method of Operating the Filters.

Sewage is distributed to the filter beds by means of pipes laid in the embankments between the beds, with about 4 outlets discharging upon each bed. These outlets are pipes about 8 inches in diameter, and, in order to check the velocity of the sewage and prevent it from washing holes in the beds, an apron of concrete has been constructed in front of each of the outlets in which a stone slab has been laid, rising about 2 inches above the level of the concrete. A baffle board hinged back of the outlet rests upon this stone and further assists in checking the velocity of the sewage.

The ordinary rate of pumping is about 200,000 gallons per hour, so that the surface of a filter bed can be flooded quickly, and, as the beds have been kept level, the sewage is distributed quite evenly at all times.

As previously stated, the character of the sewage discharged at the filtration area varies considerably during the time of pumping, the strongest sewage being that which reaches the filtration area during the first portion of each day's pumping, and as this portion of the sewage contains a much greater quantity of solid matter, which tends to clog the filter beds, 9 beds have been reserved to receive this heavy sewage, the remaining beds receiving the remainder of the sewage during other portions of the day. By this means the accumulation of solid matter upon the surfaces of the beds is confined chiefly to those which receive the heavy sewage, which require frequent raking, while the other beds need less frequent attention.

In addition to the regular filter beds two other beds have been prepared by throwing up rough embankments about them, and each is connected with one of the beds used to receive the heavy sewage. The soil was removed from these beds and the surfaces were ploughed, but they were not graded. Large quantities of the heavy sewage have been discharged upon these beds.

The usual method of operating the beds is to apply the sewage to two, three or four beds at a time, giving each bed a dose of about 200,000 gallons. In the winter only one bed is used at a time, and the flow is diverted from bed to bed hourly, giving each of the beds a dose of about 200,000 gallons. In this way, with an ordinary flow of sewage, each bed receives a dose of 200,000 gallons once in three days. With the average flow of sewage the rate of filtration over the entire area is about 66,000 gallons per acre per day.

Records have been kept of the distribution of sewage on the beds, and from these records the following table has been prepared, which gives the quantity of sewage flowing to each of the beds and the number of doses, as well as the average and maximum doses for the year 1903 : —

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Number of Bed.	Size of Bed (Acres).	Number of Doses.	Average Size of Dose (Gallons).	Maximum Size of Dose (Gallons).	Quantity of Sewage.	
					Gallons per Day.	Gallons per Day per Acre.
25,	1.00	45	161,000	300,000	20,000	20,000
26,	1.00	50	176,000	250,000	24,000	24,000
27,	0.31	99	126,000	250,000	34,000	110,000
28,	0.48	140	160,000	300,000	61,000	127,000
29,	0.48	154	144,000	300,000	61,000	127,000
30,	0.44	56	101,000	150,000	15,000	34,000
31,	0.46	70	112,000	300,000	22,000	48,000
33,	0.71	67	132,000	200,000	24,000	34,000
36,	0.44	64	116,000	200,000	20,000	45,000
37,	1.14	65	180,000	300,000	32,000	28,000
38,	0.70	65	154,000	250,000	27,000	39,000
39,	0.68	181	131,000	250,000	68,000	100,000
40,	0.75	187	135,000	350,000	69,000	92,000
41,	1.18	184	154,000	325,000	77,000	65,000
42,	0.78	174	123,000	300,000	58,000	74,000
43,	0.79	175	127,000	300,000	61,000	77,000
44,	0.71	175	127,000	282,000	61,000	86,000
45,	0.71	163	134,000	316,000	60,000	84,000
46,	1.14	170	152,000	400,000	71,000	62,000
47,	0.83	175	128,000	250,000	61,000	73,000
48,	0.72	133	126,000	250,000	46,000	64,000
49,	1.13	76	168,000	300,000	35,000	31,000
50,	0.50	38	158,000	300,000	16,000	32,000
51,	0.73	135	150,000	400,000	56,000	77,000
52,	0.73	153	143,000	400,000	60,000	82,000
53,	0.64	158	146,000	300,000	63,000	98,000
54,	1.06	143	166,000	400,000	65,000	61,000
56,	0.63	145	120,000	200,000	48,000	76,000
57,	0.80	134	120,000	200,000	44,000	55,000
Average,	0.75	123	140,000	287,000	47,000	66,000

The beds which receive the heavy sewage are cleaned three or four times a month during the warmer portion of the year in weather when it is practicable to clean them. The other beds are cleaned only twice a year, once in the spring and again in the fall.

The following table gives the average temperature of the sewage as it reached the pumping station for each month during 1903: —

Month.	Temperature (Degrees F.).	Month.	Temperature (Degrees F.).
January,	46	July,	56
February,	46	August,	57
March,	45	September,	57
April,	46	October,	55
May,	50	November,	51
June,	54	December,	47

In winter the beds are furrowed, and no trouble has been experienced in the disposal of the sewage at such times, notwithstanding the fact that very low temperatures continue for periods of many days. The records show temperatures running below zero continuously for periods of one week, and there are occasional periods of two or three days when the maximum temperature recorded during the twenty-four hours is below zero.

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Character of the Sewage.

The quantity of manufacturing waste discharged into the Pittsfield sewers is probably not large in proportion to the whole quantity, but this waste is derived from wool scouring and cloth washing, and greatly increases the strength of the sewage.

Owing to the storage of the sewage in the reservoir, and its discharge through the pumps and force main, as described, its character changes considerably in its course from the sewers to the filter beds. The variation in strength of the sewage at different hours of the day has already been referred to.

The average character of the sewage, as shown by the average of chemical analyses of monthly samples collected in 1903, is given in the following table: —

Yearly Average of Chemical Examinations of Sewage from Pittsfield.

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Oxygen Consumed.	
	Total Residue.			Loss on Ignition.			Free.	Albuminoid.					
	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.		Total.	Dis-solved.	Sus-pended.		Unfiltered.	Filtered.
1903,	90.98	42.31	48.67	55.75	18.89	36.86	1.46	.99	.23	.76	2.57	7.92	1.97

Character of the Effluent.

The effluent from the Pittsfield sewage-disposal works, as already indicated, is discharged at the edge of a high bluff, whence it flows into the Housatonic River. Practically no ground water enters the underdrains, so that the effluent represents the purified sewage diluted only by the rainfall upon the surfaces of the filters.

The average of monthly analyses of samples of the effluent from these works collected in 1903 is given in the following table: —

Yearly Average of Chemical Examinations of Effluent from the Pittsfield Sewage Purification Works.

Year.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Free.	Albuminoid.		Nitrates.	Nitrites.			
1903,	33.38	.2626	.0365	2.29	.6674	.0198	.38	13.1	.0266

PITTSFIELD.

Purification effected by the Pittsfield Sewage Filters.

From the results of the yearly averages of analyses of sewage and effluent given in the preceding tables the percentages of organic matters removed in the process of filtration, as represented by the free ammonia, albuminoid ammonia and oxygen consumed, have been calculated and are presented in the following table: —

Purification effected by the Sewage Filters at Pittsfield.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1903,	1.46	.2626	82.0	.99	.0365	96.3	7.92	.38	95.2

Cost of the Works.

The cost of constructing the purification works is shown in the following table: —

Land (100 acres),	$14,000 00
Constructing filter beds (24.78 acres),	30,000 00
Force main,	32,000 00
Pumping machinery,	9,500 00
Pumping station,	10,000 00
Reservoirs and screen house foundation,	53,000 00
Engineering and inspection,	7,000 00
Total,	$155,500 00

Cost of Maintenance of the Filters.

The cost of maintenance of the filtration area at Pittsfield during the year 1903 was $1,300. The cost of operating the pumping station was $4,700, of which the chief item was electric power, amounting to $2,500, or $4.71 per million gallons of sewage pumped.

Southbridge.

Population in 1900, 10,025.

The town is situated in the water-shed of the Quinebaug River and borders the State of Connecticut. The population is located chiefly in the three villages known as Globe Village, Southbridge and Sandersdale, all of which are close to the river.

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A public water supply was introduced into the town in 1880 and is available to the inhabitants of the three villages. The water is supplied by gravity and no record of the quantity used is kept by the company owning the works.

Sewerage System.

Sewers were first constructed in Southbridge many years ago. In 1899 the system was greatly enlarged and purification works were constructed, but the system is thus far available only to the inhabitants of the main village of Southbridge, and no sewers have been constructed in the other villages. The system at present in use consists chiefly of pipe sewers, in which the sewage is collected and conveyed by gravity to a filtration area located on the northerly side of the river, a short distance below the main village, where the sewage is applied to filter beds, the effluent from which is discharged into the Quinebaug River. The system was designed for sewage only, but many roofs and cellars are connected with the sewers.

At the end of the year 1903 there were 5.7 miles of sewers in use and 316 buildings had been connected with the system, which may be roughly classified as follows: —

Churches,	3
Factories,	4
Hotels,	5
Schoolhouses,	6
Business blocks,	13
Tenements,	285
Total,	316

The estimated population contributing sewage at the end of 1903 was 2,200.

Quantity of Sewage.

There are factories of various kinds in the village, some of which are connected with the sewerage system, but very little manufacturing waste has as yet been discharged into the sewers, so that the sewage is practically a domestic sewage.

No special precautions were taken to prevent the leakage of ground water into the sewers when they were built, and, since many of them are laid in wet soil, the quantity of leakage is large, and, as already indicated, many roofs and cellars are connected with the sewers, so that at times of storm large quantities of water enter the system. For these reasons the sewage is at times very dilute, especially in the spring, when the quantity of ground water flowing is large.

No record is kept of the quantity of sewage flowing in the sewers, but several measurements of the flow have been made by the State Board of Health, the results of two of which, made in April, 1902, and in 1903, show the approximate quantity of sewage flowing under average conditions.

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Flow of Sewage at Southbridge.

DATE.	Average Flow (Gallons per Day).	DATE.	Average Flow (Gallons per Day).
April 16-17, 1902, ...	348,000	April 23-24, 1903, ...	426,000

From these measurements and from other observations the average quantity of sewage flowing in the Southbridge sewers appears to be about 350,000 gallons per day.

The daily flow per inhabitant, etc., computed from the best information available, is approximately as follows: —

	Average Flow of Sewage (Gallons per Day).		Average Flow of Sewage (Gallons per Day).
Total flow, ...	350,000	Flow per connection, ...	1,108
Flow per inhabitant, ...	31	Flow per mile of sewer, . .	61,400
Flow per person connected with the sewers.	159		

Treatment of the Sewage before Filtration.

At the filtration area a tank has been provided to receive the sewage and discharge it intermittently upon the filter beds. The sewage as it arrives at the filtration area is passed through screens consisting of wooden slats with open spaces of three-quarters of an inch between them, the screens having a total area of 56 square feet. The flush tank is constructed of masonry with a plank cover and has a capacity of 14,200 gallons. Arrangements were made to discharge such solid matter as might accumulate on the bottom of this tank upon two sludge beds prepared for the purpose in the immediate neighborhood of the tank. The tank and sludge beds are located close to the river and not far from the main highway between Southbridge and Sandersdale, and, on account of the objectionable odor arising from this sludge when discharged upon the sludge beds, the use of the sludge beds has been discontinued, and during the past year and for a considerable time previously all of the sewage has been discharged directly upon the filter beds.

Description of the Filter Beds.

The area owned by the town for use for sewage-disposal purposes comprises 50 acres of land, much of which consists of high land, upon which the sewage cannot be discharged by gravity. The portions used for sewage-disposal purposes consist of a flat area bordering the river, the surface

of which was originally very little above the level of high water in the stream. The soil in the upper portions of the area owned by the town consists of sand and gravel underlaid by ledge. The soil of the lower portions was in places quite fine.

The filter beds border the northerly side of the river and are about 200 feet from the nearest highway, which passes along the southerly side of the river. The nearest house is about 200 feet from the filter beds, and there are about 30 dwelling houses within half a mile.

Upon the filtration area 17 filter beds have been constructed, having an aggregate area of 7.25 acres, the average size of the beds being about half an acre each, there being two sludge beds of considerably smaller size than the others.

The material of which the beds were constructed was taken chiefly from the higher land near by, which contains coarse sand and gravel well adapted to the purification of sewage, but some of the finer material found at the site of the filter beds was left in place, and the filters containing this material do not operate as freely as the others.

Underdrainage.

The filter beds are underdrained by lines of pipe laid through the centre of each bed discharging into main underdrains laid along each edge of the area, in which the effluent is conveyed to a point 550 feet below the lower beds, where it is discharged into the river. It was found before the filters were constructed that a large quantity of ground water flowed from the high land north of the filter beds to the river, through the area on which the filters are situated. The level of the river opposite the filter beds is frequently considerably higher than the level of the underdrains, and sometimes higher than the surfaces of the filter beds. The river has a rapid fall, and, by laying large main underdrains on both sides of the area and carrying the outlet a considerable distance below the area, it was practicable to keep the filter beds well underdrained and obtain a free outlet for the effluent. In addition to the underdrainage a ditch has been constructed near the edge of the high land, on the northerly side of the beds, to remove surface water flowing from this land to an outlet below the filters.

Method of Operating the Filters.

The sewage is discharged upon the filter beds through pipes discharging at one or two corners of each of the beds. The surfaces of the filter beds are very uneven, owing to unequal settlement in the filled portions and the fact that very little had been done until recently to improve their

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condition. In consequence of these conditions some parts of the filter beds received very little sewage at times, when other portions were being flooded to a considerable depth.

The ordinary method of operation is to allow the sewage to flow upon two beds at a time for two days during periods of ordinary flow, but at times of high flow four or five beds are used at a time. With this method of operation the ordinary dose is about 750,000 gallons of sewage per acre, and each bed receives sewage about once in eight days in dry weather, or at the rate of more than 90,000 gallons per acre per day, while in wet weather sewage may be applied to the beds at twice this rate.

Some attempts have been made to raise crops of corn on some of the filter beds, but they have not been successful, on account of the large quantity of sewage requiring disposal. In winter some of the beds are furrowed, but much of the sewage has been allowed to flow more or less directly into the river without purification. Solid matter collects in considerable quantities in the lower portions of the filter beds which receive the greater portion of the sewage, and this matter is removed from time to time and used as a fertilizer.

Character of the Sewage.

As already indicated, the character of the sewage varies greatly from time to time, being fairly strong in dry weather and very weak at times of wet weather.

The average yearly results of monthly analyses of the sewage are presented in the following table: —

Yearly Averages of Chemical Examinations of Sewage from Southbridge.

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Oxygen Consumed.	
	Total Residue.			Loss on Ignition.			Free.	Albuminoid.					
	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.		Total.	Dis-solved.	Sus-pended.		Unfiltered.	Filtered.
1900, .	28.12	18.30	9.82	12.57	6.70	5.87	0.80	.34	.15	.19	2.74	2.89	1.52
1901, .	39.86	15.53	24.33	27.16	7.35	19.81	1.59	.52	.23	.29	2.50	4.54	1.93
1902, .	23.27	16.13	7.14	12.99	8.38	4.61	1.95	.38	.18	.20	2.78	3.09	1.91
1903, .	28.71	17.61	11.10	15.97	7.31	8.66	1.95	.43	.25	.18	2.90	4.01	2.51

Character of the Effluent.

The yearly averages of monthly analyses of samples of the effluent from these works are given in the following table: —

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Yearly Averages of Chemical Examinations of Effluent from the Southbridge Sewage Purification Works.

[Parts per 100,000.]

Year.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
1900,	6.28	.0356	.0146	1.17	.0925	.0021	.39	1.5	.0192
1901,	7.94	.2017	.0166	1.48	.1219	.0027	.19	2.1	.0185
1902,	9.25	.2303	.0245	1.38	.1644	.0103	.27	2.4	.0346
1903,	10.96	.3865	.0369	1.74	.2036	.0126	.36	3.1	.1039

Purification effected by the Southbridge Sewage Filters.

From the results of the yearly averages of analyses of sewage and effluent given in the preceding tables the percentages of organic matters removed in the process of filtration, as represented by the free ammonia, albuminoid ammonia and oxygen consumed, have been calculated and are presented in the following table.

The effluent, as already indicated, is greatly diluted by ground water, and to show its character, making allowance for this dilution, an additional table has been prepared.

Purification effected by the Sewage Filters at Southbridge.

[Parts per 100,000.]

Year.	Free Ammonia. Sewage.	Free Ammonia. Effluent.	Free Ammonia. Per Cent. Removed.	Total Albuminoid Ammonia. Sewage.	Total Albuminoid Ammonia. Effluent.	Total Albuminoid Ammonia. Per Cent. Removed.	Oxygen Consumed. Sewage.	Oxygen Consumed. Effluent.	Oxygen Consumed. Per Cent. Removed.
1900,	0.80	.0356	95.5	.34	.0146	95.7	2.89	0.39	86.5
1901,	1.59	.2017	87.3	.52	.0166	96.8	4.54	0.19	95.8
1902,	1.95	.2303	88.2	.38	.0245	93.6	3.09	0.27	91.3
1903,	1.95	.3865	80.2	.43	.0369	91.4	4.01	0.36	91.0

Purification effected by the Sewage Filters at Southbridge, as indicated by the Calculated Analyses of the Effluent.

1900,	0.80	.1003	87.5	.34	.0411	87.9	2.89	1.10	61.9
1901,	1.59	.3564	77.6	.52	.0293	94.4	4.54	0.34	92.5
1902,	1.95	.3050	84.4	.38	.0325	91.4	3.09	0.36	88.3
1903,	1.95	.6687	65.7	.43	.0638	85.2	4.01	0.62	84.5

SOUTHBRIDGE.

Cost of the Works.

The cost of constructing the filter beds at Southbridge is shown in the following table: —

Land (50 acres),	$5,000 00
Filter beds, exclusive of the large main underdrains for the removal of ground water (7.25 acres),	7,632 34
Total,	$12,632 34

Cost of Maintenance of the Filters.

In the ordinary operation of the filter beds one man is employed all the time during the summer months. The cost of maintenance is estimated to be about $500 per year.

SPENCER.

Population in 1900, 7,627.

The town of Spencer is situated in the valley of the Seven Mile River, one of the tributaries of the Quaboag River, a principal branch of the Chicopee. The population is located chiefly in the main village, in the southerly part of the town.

A public water supply was introduced in 1883, water being taken from Shaw Pond by gravity. The supply is available to practically all of the main village of Spencer, and at the end of the year 1903 there were 13.9 miles of water pipe and 700 services in use. No measurements are made of the quantity of water used.

Sewerage System.

The construction of a sewerage system in the town of Spencer was begun in the year 1883, and at the present time the sewage of the greater portion of the main village is collected in a system of pipe sewers and conveyed by gravity to a filtration area located on the easterly side of the Seven Mile River, in the southerly portion of the town, where it is purified by intermittent filtration. The sewage of a small area in the westerly portion of the town, known as the Pleasant Street district, is discharged directly into the Seven Mile River, about one and a half miles above the filtration area.

The first sewers built in the town discharged directly into a small tributary of the Seven Mile River, flowing through the village, but in 1889 a main sewer was constructed by which the sewage was conveyed to an outlet into the river, a little over half a mile above the present filtration area.

The sewage purification system was constructed in 1897. In order to extend the main sewer by gravity to the filtration area it was necessary either to leave the highway and enter private lands or to construct the sewer for a considerable distance below the level of the proposed filter

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beds. The latter plan was adopted and an inverted siphon laid in the highway from the lower end of the main sewer to the filtration area. At the upper end of this inverted siphon there is a screen chamber designed to intercept objects which might tend to clog the siphon, and at the two low points in the siphon blow-offs have been put in and small filter beds constructed to receive the discharge from the siphon, in case it should become necessary to empty it for any purpose.

The total length of sewers constructed to the end of 1903 was 10 miles, and 600 buildings had been connected with the sewers at that time, which may be classified as follows: —

Factories,	5
Schoolhouses,	8
Business blocks,	25
Churches,	7
Public buildings,	3
Dwellings,	552
Total,	600

The estimated population contributing sewage at the end of 1903 was 3,000.

Quantity of Sewage.

While a considerable quantity of manufacturing waste results from some of the manufacturing processes carried on in the factories in the village, most of this waste has thus far been disposed of by discharging it directly into the brook flowing through the town, and little manufacturing waste is discharged into the sewers, so that the sewage is very largely domestic sewage.

Although the system was designed to provide for house sewage only, a considerable number of catch basins were connected with the sewers for the purpose of removing surface water from the streets, and the water from many roofs and cellars was also discharged into the sewers at the time when the purification works were built. Outlets were provided at various places in the sewerage system through which mingled sewage and storm water could be discharged at times of rain into the streams at convenient points. When the purification works were constructed, however, all of the catch basins formerly connected with the sewers were disconnected, but water from roofs and cellars still discharges into the sewers, increasing the flow greatly at times of storms. The sewers, moreover, were laid without any special effort to keep out ground water, and in wet weather a very large quantity of ground water finds its way into the sewers through cracks or defective joints in the pipes and in other ways. In consequence of these conditions there are great variations in the flow in the sewers.

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No record is kept of the quantity of sewage flowing, but occasional measurements have been made by the State Board of Health, the results of which are presented in the following table: —

Date.	Average Flow (Gallons per Day).	Date.	Average Flow (Gallons per Day).
June 14-15, 1898,	369,000	April 28-29, 1902,	550,000
August 3-4, 1899,	343,000	April 29-30, 1903,	617,000

From these and other observations it appears that the ordinary flow of sewage, when not increased by surface water, is about 375,000 gallons per day during the summer months, and at times of wet weather, during days when it is not storming, this amount is increased to about 550,000 gallons. During storms the flow is very much in excess of the latter figure.

The daily flow per inhabitant, per mile of sewer, etc., computed from the limited information available, is given in the following table: —

	Average Flow of Sewage (Gallons per Day).
Total flow,	375,000
Flow per inhabitant,	49
Flow per person connected with the sewers,	125
Flow per connection,	625
Flow per mile of sewer,	37,500

Treatment of the Sewage before Filtration.

The sewage, before entering the inverted siphon leading to the filtration area, passes through a screen chamber located at the side of the highway and covered by a wooden building. The screens consist of iron plates with an open space of three-quarters of an inch between them, arranged in the form of a rectangle. In this way a large screen area is made available in a small space, the total area being about 70 square feet. Ordinarily these screens are cleaned two or three times a day and three or four wheel-barrow loads of material are removed daily. The screens clog rapidly, however, and, unless cleaned frequently, the sewage backs up in the main sewer and discharges over a weir into the former outlet leading to the Seven Mile River, and, while the screens receive quite regular attention, much sewage finds its way directly into the river through this outlet on account of the clogging of the screens.

At times of high flow in the sewers considerable quantities of the organism *Leptomitus*, a fungus which grows upon the inner surfaces of the sewers, become detached and aid materially in causing the rapid clogging of the screens.

From the screen chamber the sewage enters the inverted siphon, which

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is 12 inches in diameter and has a total length of 3,127 feet. The difference in elevation between the two ends of the siphon is 16.8 feet, and there are two depressions, at the lowest points of which blow-offs have been constructed through which the contents of the siphon can be discharged upon two filter beds which have been prepared for the purpose. One of the beds which receive the contents of the siphon is located beside the river near the former main sewer outlet. The other is adjacent to the filtration area near the lower end of the siphon. These blow-offs are used quite frequently, and the sewage in the main sewer above the siphon is sometimes held back for a time in order to obtain a greater velocity when the siphon is emptied. It does not appear that stoppages have occurred in the siphon or that it is essential to open these blow-offs or use the screens in order to keep the siphon in operation. The inverted siphon contains about 18,400 gallons of sewage, and with the average flow the velocity through the siphon is about .75 of a foot per second. With a maximum flow the velocity is about 1.1 feet per second.

Description of the Filter Beds.

The area purchased by the town for filtration purposes comprises 22.25 acres adjacent to the Seven Mile River and near the boundary line between the towns of Spencer and Brookfield. There is one dwelling house upon the area, which is occupied by the care-taker of the filter beds, but aside from this house there are only 8 or 10 dwelling houses within a mile of the area. The contour of this area was originally very uneven, much of the land being swampy, but a high gravel ridge extended along one side of the area. The filter beds were prepared by removing the gravel from the higher portions of the ridge and filling the low places.

Twelve filter beds have been prepared, having a combined area of 9.3 acres, or an average area of .78 of an acre each. The largest bed has an area of about an acre and the smallest about .3 of an acre.

The character of the material of which the filter beds are composed, as determined from samples collected from the middle of each of the beds, is shown in the following table: —

Analyses of Filtering Material of the Spencer Filter Beds.

Depth Below Surface (Feet).	Effective Size (Millimeters).			Uniformity Coefficient.			Albuminoid Ammonia (Parts per 100,000).		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
Surface,	.34	.65	.13	10.6	19.5	4.9	28.9	91.2	2.1
0.25,	.29	.48	.12	10.0	20.0	4.9	18.1	51.3	4.2
0.5,	.31	.47	.10	8.8	15.5	4.1	13.5	46.8	3.0
1.0,	.24	.41	.08	9.7	26.3	2.5	8.3	24.0	2.2
2.5,	.18	.25	.06	4.2	7.1	2.0	3.1	5.9	1.0

Underdrainage.

In three of the beds, situated at the southerly end of the area, the ground water level was not far from the surface, and these beds were underdrained by lines of tile pipe laid 60 feet apart and 6 feet beneath the surface. The remaining beds are not underdrained, as the material is very coarse and porous and the ground water level is at a considerable distance below the surfaces of the beds.

The underdrains discharge directly into the Seven Mile River.

Method of Operating the Filters.

The sewage is discharged continuously on the filter beds at the corners, and upon most of the beds sewage is discharged at two points. Ditches have been constructed along the sides of the beds which receive the sewage, from which it flows upon the filter beds through small openings in the sides of the ditches. The sides of the ditches adjacent to the beds are sodded in order to prevent them from washing away, and very little trouble has been experienced from this cause.

It was found that in times of dry weather, when the flow of sewage was small, it was impossible to secure an even distribution of the sewage over the filter beds, and, in order to improve this condition, low embankments were constructed across the middle of each of the larger beds, dividing them into two parts; but at times, when the flow of sewage is small, it has been found difficult, even after dividing the beds, to distribute the sewage properly over the area, that portion near the carrier from which the sewage is distributed receiving practically all of the flow, while the portions near the middle of the bed receive but little sewage. In the winter and spring, with larger flows, however, the beds are flooded without difficulty.

The usual method of operating the filters is to apply the sewage to two beds at the same time during the daytime and to discharge the flow on three of the beds during the night. Sometimes, at times of high flow, four beds are used at a time. In this way about half of the beds are used each day. In cold weather in winter, especially when the flow is low, the whole flow of twenty-four hours is sometimes applied to two beds, one being used during the daytime and the other during the night.

With the average flow of sewage the rate of filtration over the whole area is about 40,000 gallons per acre per day, while at times of high flow the quantity purified amounts to as much as 80,000 gallons per acre per day. Since the beds are used approximately every other day, the average doses applied amount to about 80,000 gallons per acre in dry weather and to double this amount in wet weather.

In the fall the beds are prepared for winter by running a harrow over them after they are cleaned, which leaves the surfaces irregular, but does

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not leave high ridges, such as are produced by the plough. In summer the beds are raked once or twice and a corn crop is raised upon them. The corn crop has not been very successful, as the quantity of sewage in summer has not been sufficient to irrigate the corn properly.

Very little solid matter accumulates upon the surfaces of the beds. The beds are cleaned each fall, the material removed being used as a fertilizer or deposited on low ground.

No difficulty has been experienced in operating the filters during the coldest weather, when, for periods of several days, the minimum temperature falls below zero F. The temperature of the sewage as it is discharged upon the filter beds in the coldest weather has been observed to be about 44° F.

Character of the Sewage.

The sewage of Spencer varies greatly in quality at different seasons of the year on account of the variations in the quantity of ground and surface water finding their way into the sewers. During the wetter portion of the year, in the winter and spring, the sewage is usually very weak and at times of storm is still further diluted. As already indicated, the sewage is largely domestic sewage and the quantity of manufacturing waste discharged into the sewers is small.

The distance from the centre of the town to the filtration area is about two miles, and the sewer leading from the town to the filtration area has a steep slope, so that the sewage passes quickly to the filtration area and arrives there in a very fresh condition, though the solid matters are considerably broken up by the rapid flow.

The average character of the sewage, as shown by chemical analyses of monthly samples since the purification works were completed, is given in the following table: —

Yearly Averages of Chemical Examinations of Sewage from Spencer.

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Oxygen Consumed.	
	Total Residue.			Loss on Ignition.			Free.	Albuminoid.				Unfiltered.	Filtered.
	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.		Total.	Dis-solved.	Sus-pended.			
1898, . .	28.47	18.97	9.50	14.44	6.24	8.20	1.45	.49	.23	.26	4.05	2.84	1.51
1899, . .	29.32	16.81	12.51	16.43	6.11	10.32	1.62	.47	.19	.28	3.08	3.29	1.71
1900, . .	32.69	18.76	13.93	18.54	7.21	11.33	1.70	.57	.23	.34	3.38	4.86	3.09
1901, . .	30.42	17.30	13.12	16.42	6.90	9.52	1.24	.45	.20	.25	3.08	3.31	1.77
1902, . .	43.64	23.05	20.59	24.18	9.78	14.40	1.78	.68	.24	.44	3.93	4.85	2.74
1903, . .	35.78	24.34	11.44	20.22	10.06	10.16	1.81	.55	.31	.24	3.99	4.65	2.74

SPENCER.

Character of the Effluent.

The effluent from the Spencer purification works, as shown by the results of analyses of samples collected from the underdrains, is very thoroughly purified. The results of yearly averages of analyses are presented in the following table: —

Yearly Averages of Chemical Examinations of Effluent from the Spencer Sewage Purification Works.

[Parts per 100,000.]

Year.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Free.	Albuminoid.		Nitrates.	Nitrites.			
1898, ...	18.77	.2669	.0411	3.19	.9618	.0511	.45	5.4	.0059
1899, ...	15.86	.1013	.0156	2.48	.7025	.0014	.12	4.0	.0018
1900, ...	15.22	.2333	.0126	2.79	.6894	.0029	.18	3.8	.0076
1901, ...	16.32	.2895	.0185	3.03	.5197	.0079	.21	4.3	.0268
1902, ...	17.12	.2014	.0128	2.78	.3845	.0118	.15	4.2	.0617
1903, ...	17.95	.1484	.0186	3.16	.3691	.0248	.33	6.1	.3542

Purification effected by the Spencer Sewage Filters.

From the results of the analyses of sewage and effluent given in preceding tables the percentages of organic matters removed in the process of filtration, as represented by the free ammonia, albuminoid ammonia and oxygen consumed, have been calculated and are presented in the following table. Tables are also appended showing, in a similar way, the purification effected in the six warmer months of the year, from June to November, inclusive, and in the six colder months, from December to May, inclusive.

Purification effected by the Sewage Filters at Spencer.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1898, ...	1.45	.2669	81.6	.49	.0411	91.6	2.84	.45	84.2
1899, ...	1.62	.1013	93.7	.47	.0156	96.7	3.29	.12	96.4
1900, ...	1.70	.2333	86.3	.57	.0126	97.8	4.86	.18	96.3
1901, ...	1.24	.2895	76.7	.45	.0185	95.9	3.31	.21	93.7
1902, ...	1.78	.2014	88.7	.68	.0128	98.1	4.85	.15	96.9
1903, ...	1.81	.1484	91.8	.55	.0186	96.6	4.65	.33	92.9

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Purification effected by the Sewage Filters at Spencer during the Summer Months (from June to November, inclusive) of Each Year.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1898,	1.28	.0500	96.1	.51	.0095	98.1	3.44	.18	94.8
1899,	2.04	.0651	96.8	.52	.0094	98.2	3.65	.13	96.4
1900,	2.03	.2502	87.7	.70	.0105	98.5	3.79	.20	94.7
1901,	1.42	.1893	86.7	.44	.0153	96.5	2.77	.19	93.1
1902,	2.36	.1465	93.8	.75	.0110	98.5	5.20	.13	97.5
1903,	2.30	.1461	93.6	.73	.0180	97.5	5.67	.37	93.5

Purification effected by the Sewage Filters at Spencer during the Winter Months (from December to May, inclusive) of Each Year.

1898,	1.65	.4345	73.7	.51	.0650	87.3	2.80	.67	76.1
1899,	1.11	.1307	88.2	.38	.0226	94.1	2.22	.10	95.5
1900,	1.45	.2279	84.3	.48	.0138	97.1	6.28	.18	97.1
1901,	1.18	.3839	67.5	.45	.0218	95.2	3.78	.22	94.2
1902,	0.92	.2437	73.5	.48	.0138	97.1	3.42	.09	97.4
1903,	1.43	.1535	89.3	.50	.0163	96.7	4.14	.26	93.7

As already stated, a considerable quantity of sewage is discharged into the river at Spencer without purification, but such disposal has never been necessary, since the filter beds are of ample capacity to purify all of the sewage flowing in the sewers of the town. Sewage is not only discharged through the overflow but is at times discharged continuously through one of the blow-offs from the siphon upon one of the small filter beds, whence it overflows into the river. This has been done for convenience chiefly at times when the main filter beds are being cleaned and is entirely unnecessary.

Cost of the Works.

The cost of the construction of the Spencer sewage-disposal works is shown by the following table: —

Filter beds (9.3 acres),	$8,273 00
Land for filter beds (22.25 acres),	1,600 00
Force main,	1,400 00
Screen chamber,	294 00
Screens,	63 00
Total,	$11,630 00

Cost of Maintenance of the Filters.

The following table gives the annual cost of maintaining the beds since they were put in operation: —

1898,	$938 53
1899,	1,327 51
1900,	904 09
1901,	928 22
1902,	729 36
1903,	800 00

The amount realized by the sale of corn raised on the filter beds during the past six years (and which should be deducted from the cost of maintenance, as given above) is as follows: —

1898,	$40 72
1899,	73 70
1900,	96 25
1901,	70 00
1902 (not planted),	-
1903,	52 00

STOCKBRIDGE.

Population in 1900, 2,081.

The town of Stockbridge is situated in the water-shed of the Housatonic River, its principal village being located on the right, or westerly, bank of the stream, in the southerly part of the town.

A public water supply was introduced into this village many years ago, and at the present time the village is supplied with water by gravity from Lake Averic. At the end of the year 1903 there were 8 miles of water mains in use, with which there were 222 connections. No record is kept of the quantity of water used, though estimates indicate that it is in the neighborhood of 300,000 gallons per day.

Sewerage System.

The sewerage system of the town was constructed in 1899. It consists of a system of pipe sewers by which the sewage is collected and conveyed by gravity to a filtration area, located near the Housatonic River, northwest of the village, where it is purified by filtration, the effluent being discharged into the Housatonic River.

The total length of sewers constructed at the end of the year 1903 was 3.5 miles and there were 107 connections with the sewers.

The estimated population contributing sewage is 800.

STOCKBRIDGE.

Quantity of Sewage.

There are no factories in the village of Stockbridge and the sewage is strictly a domestic sewage. Great care was taken in the construction of the sewers to prevent the entrance of ground water, and underdrains were laid beneath them wherever the soil contained considerable quantities of water, the drains discharging into convenient water courses. In one very wet locality the main sewer, for a distance of 600 feet, was constructed of iron pipe. At the upper ends of 10 lateral sewers, flush tanks were put in which have a capacity of 150 gallons, and are intended to discharge once in twenty-four hours.

The main sewer from the town to the filtration area is 12 inches in diameter and laid on a grade of 1 in 1,000. A flush tank having a capacity of 2,000 gallons is located at the upper end of this sewer, and a siphon is provided to discharge the sewage from the tank automatically. Examinations have shown, however, that much of the time the siphon does not operate and that the flow through the main sewer is continuous.

No records are kept of the quantity of sewage flowing in the sewers, but occasional measurements have been made by the State Board of Health. Two twenty-four hour measurements made on May 19 and 20, 1902, and on May 11 and 12, 1903, at a time when there had been no rain for several days, gave the following results: —

Flow of Sewage at Stockbridge.

Date.	Average Flow (Gallons per Day).	Date.	Average Flow (Gallons per Day).
May 19-20, 1902, ...	66,900	May 11-12, 1903, ...	133,000

These measurements, together with other observations which have been made, indicate that the average flow is about 75,000 gallons per day. The average daily quantity of sewage per inhabitant, per person connected, per connection and per mile of sewer, for the year 1903, is as follows: —

	Average Flow of Sewage (Gallons per Day).		Average Flow of Sewage (Gallons per Day).
Total flow, ...	75,000		
Flow per inhabitant, . . .	36	Flow per connection, . . .	700
Flow per person connected with the sewers.	94	Flow per mile of sewer, . .	21,430

STOCKBRIDGE.

Treatment of the Sewage before Filtration.

At the filtration area the sewage passes through screens and enters a flush tank, from which it is discharged intermittently to the filtration area. The first screen has an area of 42 square feet and is constructed of galvanized iron bars, the spaces between the bars being three-quarters of an inch. The screen is 6 feet in width, and a portion 4 feet long is laid horizontally about 6 inches above the bottom of the tank, so that this portion of the area, amounting to about 24 square feet, is in use at all times, the sewage passing downward into the chamber. The remaining portion of the first screen is at an angle of about 60 degrees with the other portion, and this incline is available only as the tank fills with sewage. After passing the first screen the sewage passes through a second screen having an area of 8 square feet, with spaces of half an inch between the bars. This screen is set vertically, and the whole area becomes available only when the tank is full of sewage. The screenings, amounting to about two wheel-barrow loads each day, are removed and buried in the neighborhood.

The flush tank is 40 feet square and provides for a maximum depth of sewage of 1½ feet, this small depth being necessary on account of the slight fall available between the village and the filtration area. Its capacity, including the capacity of the main sewer, into which the sewage backs up as the tank becomes full, is a little over 20,000 gallons. The inside walls of the tank and of the screen chamber are lined with white enamelled brick, and the tank is uncovered in the summer season. In the winter the tank is protected from the weather by a covering of planks laid loosely across I-beams, which span the tank. The tank is discharged intermittently through an automatic siphon. A deposit of solid matter accumulates in the bottom and is removed from time to time, as the tank is emptied, by flushing with a hose. The bottom and sides of the tank are thoroughly cleaned every day during the summer when the tank is uncovered and once in two weeks during the winter.

Description of the Filter Beds.

The area purchased by the town for filtration purposes, including the land on which the town almshouse is situated, comprises 29 acres, located between the highway leading from Stockbridge to West Stockbridge and the Housatonic River. The nearest house is one situated on the area and used by the town as an almshouse. There are no other dwelling houses within half a mile of the filter beds. The area slopes quite gradually from the highway toward the river, but near the river the land is low and subject to overflow at times of high water.

The area prepared for the purification of sewage consists of 4 sand filter beds having an aggregate area of one acre, and a bed having an area of about 2.6 acres prepared for irrigation purposes, with a gradual slope from

STOCKBRIDGE.

the tank toward the river. This area contains much fine material and much of the surface soil removed in preparing the filter beds.

The character of the soil in the filter beds is shown by the following table of analyses of samples collected at various depths from the middle of each of the beds: —

Analyses of Filtering Material of the Stockbridge Filter Beds.

Depth below Surface (Feet).	Effective Size (Millimeters).			Uniformity Coefficient.			Albuminoid Ammonia (Parts per 100,000).		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
Surface,	.17	.23	.13	13.8	28.5	6.4	47.14	87.50	27.28
0.25,	.20	.45	.10	14.6	33.1	5.8	37.05	82.48	8.23
0.50,	.21	.50	.11	14.1	25.9	6.7	23.64	64.92	9.33
1.00,	.27	.60	.10	11.7	28.1	5.9	26.53	51.56	6.06
2.00,	.17	.20	.14	11.9	25.0	2.1	13.12	17.61	6.23

Underdrainage.

The sand filter beds are underdrained by lines of tile pipe laid 23 feet apart discharging into a man-hole near one corner of the area, from which the effluent flows to the river. The irrigation area has a slope of 3.3 feet from the upper to the lower edge, — a distance of 330 feet, — and is underdrained by lines of pipe laid 30 feet apart and from 3 to 4.5 feet beneath the surface, which discharge into the same man-hole as that which receives the effluent from the filter beds.

Method of Operating the Filters.

The sewage is applied to the sand filter beds through a number of outlets on the sides of each of the beds. In winter the beds are not furrowed but are left with smooth surfaces, and are apparently used but little in the winter season for the disposal of the sewage, all of the sewage being discharged upon the irrigation bed.

The sewage is applied to the irrigation bed through 40 outlets, consisting of short pipes discharging at the surface of the soil, at the upper edge of the area. During the summer each of the sand filter beds and each half of the irrigation area receives the flow of sewage continuously for twenty-four hours, so that each filter bed and each half of the irrigation area receives a day's flow of sewage once in six days.

With the average quantity of sewage flowing the sand filter beds, therefore, receive sewage at the rate of about 300,000 gallons per acre once in

six days, or 50,000 gallons per acre per day, while the irrigation area receives sewage at the rate of 150,000 gallons once in six days, or 10,000 gallons per acre per day. During the winter the rate of application of sewage to the irrigation area is increased to about 30,000 gallons per acre per day.

No crops are raised on the filter beds. In the earlier years of the operation of the works a crop of corn was raised upon the irrigation bed, but in recent years this bed has been planted with grass.

The sewage tends to collect at the lower edge of the irrigation bed in the winter season, but no evidence has been obtained that any of the sewage flows directly into the river without purification. In the winter season the sewage finds its way beneath the ice on this area and settles into the ground, and is disposed of without difficulty, even at times of extremely cold weather. During good weather each filter bed is raked and cleaned after each dose of sewage. The irrigation area is ploughed each spring and receives no other attention.

Character of the Sewage.

The sewage of Stockbridge is a strictly domestic sewage, and thus far the analyses show that it is very weak. It has but little odor and very little odor is noticeable about the filter beds.

The average character of the sewage, as shown by chemical analyses of monthly samples, is indicated in the following table : —

Yearly Averages of Chemical Examinations of Sewage from Stockbridge.

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Oxygen Consumed.	
	Total Residue.			Loss on Ignition.			Free.	Albuminoid.				Unfiltered.	Filtered.
	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.		Total.	Dis-solved.	Sus-pended			
1900, .	25.23	18.83	6.40	11.12	5.97	5.15	1.18	.26	.14	.12	1.63	2.09	1.48
1901, .	23.18	16.66	6.52	11.99	6.93	5.06	1.43	.19	.11	.08	1.83	1.97	1.32
1902, .	27.02	18.64	8.38	15.16	8.33	6.83	1.36	.27	.15	.12	1.38	1.73	1.28
1903, .	23.56	19.51	4.05	8.80	5.71	3.09	1.19	.20	.11	.09	1.28	1.52	0.96

Character of the Effluent.

Samples of the effluent have been collected both from the filter beds and from the irrigation area. The purification effected by the filter beds is somewhat better than that of the irrigation area, but in general all of the sewage is well purified. The results of the analyses of the effluent are presented in the following tables : —

STOCKBRIDGE.

Yearly Averages of Chemical Examinations of Effluent from the Sand Filter Beds, Stockbridge.

[Parts per 100,000.]

Year.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
1901, ...	21.69	.1789	.0369	2.17	.2325	.0027	.37	9.3	.0378
1902, ...	19.75	.2246	.0245	1.86	.3005	.0040	.37	9.6	.0656
1903, ...	20.07	.1056	.0217	1.91	.1439	.0024	.33	9.6	.1289

Yearly Averages of Chemical Examinations of Effluent from the Irrigation Area, Stockbridge.

Year.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
1901, ...	20.60	.1686	.0464	2.11	.1578	.0028	.43	9.5	.0623
1902, ...	19.72	.1804	.0352	1.55	.2245	.0161	.36	10.5	.0741
1903, ...	19.84	.0924	.0198	1.71	.1822	.0027	.28	10.0	.1288

Purification effected by the Stockbridge Sewage Filters.

The results of the yearly averages of analyses of sewage and effluent, showing the percentages of organic matters removed both by the filter beds and by the irrigation bed, have been calculated and are presented in the following tables: —

Purification effected by Sand Filter Beds at Stockbridge.

[Parts per 100,000.]

Year.	Free Ammonia. Sewage.	Free Ammonia. Effluent.	Free Ammonia. Per Cent. Removed.	Total Albuminoid Ammonia. Sewage.	Total Albuminoid Ammonia. Effluent.	Total Albuminoid Ammonia. Per Cent. Removed.	Oxygen Consumed. Sewage.	Oxygen Consumed. Effluent.	Oxygen Consumed. Per Cent. Removed.
1901, ...	1.43	.1789	87.5	.19	.0369	80.6	1.97	.37	81.2
1902, ...	1.36	.2246	83.5	.27	.0245	90.9	1.73	.37	78.6
1903, ...	1.19	.1056	91.1	.20	.0217	89.1	1.52	.33	78.3

Purification effected by the Irrigation Area at Stockbridge.

Year.	Free Ammonia. Sewage.	Free Ammonia. Effluent.	Free Ammonia. Per Cent. Removed.	Total Albuminoid Ammonia. Sewage.	Total Albuminoid Ammonia. Effluent.	Total Albuminoid Ammonia. Per Cent. Removed.	Oxygen Consumed. Sewage.	Oxygen Consumed. Effluent.	Oxygen Consumed. Per Cent. Removed.
1901, ...	1.43	.1686	88.2	.19	.0464	75.6	1.97	.43	78.2
1902, ...	1.36	.1804	86.7	.27	.0352	87.0	1.73	.36	79.2
1903, ...	1.19	.0924	92.2	.20	.0198	90.1	1.52	.28	81.6

Cost of the Works.

The cost of land for the filtration area of Stockbridge was $1,500. The cost of the filter beds, the irrigation area, tank and screens was $8,238.

Cost of Maintenance of the Filters.

For the maintenance of the works, one man is employed part of the time, who gives the remainder of his time to the care of the adjacent poor farm, and he is assisted at times when the beds require cleaning. The total annual cost of maintenance is estimated to be about $600.

WESTBOROUGH.

Population in 1900, 5,400.

The town is situated partly within the water-shed of the Sudbury River, above the point at which the water of this stream is taken for the supply of the metropolitan district, and partly within the water-shed of the Assabet River, the principal part of the population, including all of the main village, being within the water-shed of the Sudbury River. Two large public institutions, the Lyman School for Boys and the Westborough Insane Hospital, are situated in this town.

A public water supply was introduced in 1879 from Sandra Pond in Westborough, and at the end of the year 1903 there were 14.5 miles of water pipes and 650 services in the town. Water is supplied from the public works to the Lyman School for Boys, but the Westborough Insane Hospital is supplied from independent works.

Sewerage System.

The sewerage system of the town was constructed in 1891 and 1892. The sewage of the main village and from the Lyman School for Boys is collected in a system of pipe sewers and conveyed by gravity to filter beds near the Assabet River, about one and one-half miles north-west of the main village, where it is purified by intermittent filtration after the removal of a small portion of the solid matter by sedimentation, the effluent being discharged into the Assabet River.

At the end of the year 1903 there were 7.25 miles of sewers in use, and 280 buildings had then been connected with the system, which may be classified as follows: —

Dwelling houses,	252
Business blocks,	12
Factories,	5
Schoolhouses,	5
Hotels,	3
Churches,	1
State institutions,	2
Total,	280

The estimated population contributing sewage at the end of the year 1903 was 3,000.

Quantity of Sewage.

The sewage of Westborough is chiefly domestic sewage, there being no factories or mills in the town which contribute any considerable quantity of manufacturing waste.

The largest contributor of sewage is the Lyman School for Boys, the sewers from which were connected with the Westborough system in 1902. The sewage of this institution enters the main sewer near the filtration area.

WESTBOROUGH.

The sewers of Westborough are constructed on the separate plan, and surface water is excluded, but a few cellar drains are connected with the sewers. No underdrains were laid beneath the sewers. The main sewer from the town to the filtration area was laid through a considerable portion of its length in wet meadow land, and the leakage in this portion of the system was excessive until the greater portion of this main was reconstructed in 1900.

Measurements of the flow of sewage at different points in this main sewer were made in April, 1899, to determine the leakage, and the results are presented in the following table: —

From	Distance (Feet).	Leakage into Sewer.	
		Gallons per Day.	Gallons per Day per Mile of Sewer.
Man-hole No. 7* to man-hole No. 12,	1,060	122,000	608,000
Man-hole No. 12 to man-hole No. 15,	840	268,000	1,686,000
Man-hole No. 15 to man-hole No. 19,	1,110	221,000	1,050,000

* Located about 1,700 feet from the filtration area.

The lower end of the sewer for a distance of 1,700 feet from the filtration area is laid much of the way in embankment and above the level of the ground water. The leakage between the upper end of this section and man-hole No. 19 (near the village, but below all house connections and connections from tributary sewers, — a distance of 3,010 feet) was at this time 611,000 gallons per day, or more than 1,000,000 gallons per mile of sewer.

In the portion of the main sewer in which this great leakage occurred the organism *Leptomitus* grew on the inner surface of the pipe, and at times the quantity was so great as to completely obstruct the sewer, so that sewage would flow out of the man-holes. At times of high flow, when the velocity in the sewer was increased, large masses of this organism would become detached, and, flowing upon the filter beds, rapidly formed a layer upon the surface preventing the passage of the sewage into the sand. After the rebuilding of the main sewer and exclusion of the greater portion of the leakage, this organism practically disappeared, and no further trouble has been occasioned by it either in the sewers or at the filter beds.

No record of the quantity of sewage flowing in the sewers has been kept by the town authorities, but approximate measurements have been made by the metropolitan water and sewerage board and by the State Board of Health. Previous to the time of the reconstruction of the main sewer the quantity of sewage flowing was very variable, being as high in times of wet weather as 750,000 gallons per day for considerable periods, while at other

times the flow would fall to 250,000 gallons per day. Since the reconstruction of the main sewer the principal leakage in this section has been through the masonry of which the man-holes are constructed, and the average flow of sewage is much less than formerly.

The following table gives the results of measurements of the flow of sewage from the Westborough sewers, taken from the records of the metropolitan water and sewerage board: —

Flow of Sewage at Westborough from Records of Metropolitan Water and Sewerage Board.

[Gallons per Day.]

Month.	Average.	Maximum.	Minimum.
1901.			
January,	-	-	-
February,	-	-	-
March,	260,000	552,000	176,000
April,	357,000	545,000	230,000
May,	368,000	526,000	267,000
June,	180,000	504,000	71,000
July,	95,000	193,000	72,000
August,	100,000	176,000	72,000
September,	101,000	194,000	106,000
October,	94,000	143,000	71,000
November,	118,000	194,000	71,000
December,	253,000	545,000	71,000
Year,	193,000	552,000	71,000
1902.			
January,	-	-	-
February,	-	-	-
March,	-	-	-
April,	-	-	-
May,	-	-	-
June,	-	-	-
July,	-	-	-
August,	-	-	-
September,	62,000	113,000	81,000
October,	84,000	144,000	71,000
November,	147,000	176,000	135,000
December,	417,000	551,000	168,000
1903.			
January,	395,000	600,000	258,000
February,	363,000	458,000	268,000
March,	571,000	800,000	435,000
April,	414,000	551,000	277,000
May,	236,000	326,000	168,000
June,	333,000	676,000	143,000
July,	274,000	418,000	194,000
August,	146,000	194,000	71,000
September,	131,000	160,000	113,000
October,	181,000	328,000	120,000
November,	160,000	185,000	113,000
December,	193,000	230,000	143,000
Year,	282,000	800,000	71,000

The following table gives the average, maximum and minimum daily flow per inhabitant, per mile of sewer, etc., taken from the records of the metropolitan water and sewerage board, for the year 1903: —

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	Flow of Sewage (Gallons per Day).		
	Average.	Maximum.	Minimum.
Total flow,	282,000	800,000	71,000
Flow per inhabitant,	51	145	13
Flow per person connected with the sewers,	94	267	24
Flow per connection,	1,007	2,857	254
Flow per mile of sewer,	38,897	110,345	9,793

Treatment of Sewage before Filtration.

The sewage as it arrives at the filtration area enters a screen chamber, whence it flows through two screens into settling tanks, each screen being 5 feet wide and 4 feet deep, the bottom being about 1 foot below the bottom of the sewer. The screens are constructed of iron bars spaced half an inch apart. Screens of wire of diagonal mesh were formerly used but rapidly became clogged, and their use has been discontinued. The screens are cleaned each day, and as much as possible of the material which accumulates on them is forced through the screens, nothing being removed except rags and bulky substances which will not pass the screens.

The settling tanks have a combined capacity of about 800 gallons, and at a time of average flow of sewage the sewage would be about 5 minutes in passing through the tanks. The tanks are emptied about once in three days, the contents being discharged through gates in the bottoms of the tanks into a pit dug at the side of the screen house, where this matter remains until it has become sufficiently dry to be shovelled into carts, when it is carted away and used as a fertilizer. The pit is emptied about three or four times a year, and the total quantity of material removed yearly amounts to about 70 cart loads.

Description of the Filter Beds.

The area purchased by the town for filtration purposes comprises 33 acres and consists in part of high land, but chiefly of meadow land bordering the Assabet River. The level of the outlet of the main sewer at a point where it reaches the filter beds is about 6 feet above the ordinary high-water level of the Assabet River in the spring when the meadow land is overflowed, and of the 33 acres owned by the town 18 acres are subject to overflow by the river.

There is very little population in the neighborhood of the filtration area, the nearest dwelling house being 1,200 feet distant, and within a radius of 2,500 feet there are but seven dwelling houses. The Boston and Worcester turnpike, over which there is a large travel, crosses the Assabet River about 1,300 feet west of the filters.

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Upon this area 7 filter beds have been constructed, having an aggregate area of 4 acres. Five of these beds, having an area of 3 acres, have been constructed entirely of material taken from high gravelly land about a quarter of a mile from the filter beds. The remaining beds were constructed in part of material found upon the area.

The character of the material of which the filter beds are composed, as determined from samples collected from the middle of each of the beds, is shown by the following table: —

Analyses of Filtering Material of the Westborough Filter Beds.

Depth below Surface (Feet).	Effective Size (Millimeters).			Uniformity Coefficient.			Albuminoid Ammonia (Parts per 100,000).		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
Surface,	.57	.80	.24	9.1	16.9	4.6	47.97	146.00	3.68
0.25,	.34	.52	.23	7.6	15.3	5.0	10.63	23.02	3.59
0.50,	.32	.55	.20	5.9	8.2	3.8	7.76	15.70	3.44
1.00,	.30	.58	.23	9.1	13.7	4.6	6.86	15.61	2.71
2.00,	.37	.61	.20	6.4	8.4	3.0	5.14	8.44	1.60

Underdrainage.

The filter beds are underdrained by lines of pipes laid at the bottom of the filled material about 5 feet beneath the surface of the filters and from 30 to 40 feet apart. Three of the beds drain into a single main underdrain, discharging into a ditch leading to the Assabet River. The remaining four beds discharge through two separate outlets at the edge of the meadow land not far from the river.

Method of Operating the Filters.

The sewage is delivered upon the filter beds as fast as it arrives at the filtration area, there being no dosing tank, and is discharged upon the beds at from two to four outlets located about the sides of the beds. The sewage enters the sand very quickly in the immediate neighborhood of the outlets and ordinarily reaches only a small proportion of the area of the beds.

The usual method of operating the filters is to allow the sewage to flow upon one or two beds for long periods, occasionally changing the flow, with little apparent regularity. The filters receive but little attention, and, in consequence of the method of application, portions of the beds which receive sewage are greatly overworked at times, though there is ample area for the thorough purification of all of the sewage. Very little solid matter collects upon the surfaces of the beds. The filter beds are not prepared

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for the winter by furrowing but are allowed to remain level, and no trouble has thus far been experienced in this method of operating the beds, even in the coldest weather. During the summer season the beds, or portions of them, are raked about once each week.

Character of the Sewage.

On account of the large quantity of ground water which still enters the sewers, the sewage of Westborough is usually weak at times of wet weather.

The average character of the sewage, as shown by chemical analyses of monthly samples, is indicated in the following table: —

Yearly Averages of Chemical Examinations of Sewage from Westborough.

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Oxygen Consumed.	
	Total Residue.			Loss on Ignition.			Free.	Albuminoid.					
	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.		Total.	Dissolved.	Suspended.		Unfiltered.	Filtered.
1900, .	25.27	16.16	9.11	13.85	6.22	7.63	1.94	.41	.23	.18	2.59	2.82	1.84
1901, .	67.27	13.85	53.42	32.27	4.93	27.34	1.19	.59	.17	.42	2.41	4.24	1.74
1902, .	46.87	21.45	25.42	28.51	8.84	19.67	2.57	.79	.24	.55	2.90	5.03	2.31
1903, .	37.01	18.68	18.33	21.30	7.61	13.69	1.68	.54	.21	.33	2.37	3.55	1.50

Character of the Effluent.

The yearly averages of the analyses of monthly samples of the effluent are given in the following table: —

Yearly Averages of Chemical Examinations of Effluent from the Westborough Sewage Purification Works.

[Parts per 100,000.]

Year.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Free.	Albuminoid.		Nitrates.	Nitrites.			
1900, ...	15.57	.5331	.0969	2.80	0.2140	.0110	.80	3.6	.0458
1901, ...	17.17	.4708	.0622	2.29	0.7015	.0239	.56	4.1	.0497
1902, ...	22.32	.4983	.0683	2.14	1.4392	.1994	.52	6.0	.0447
1903, ...	15.54	.6410	.0849	2.22	0.3571	.0528	.73	3.8	.0469

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Purification effected by the Westborough Sewage Filters.

From the results of the yearly analyses of sewage and effluent given in the preceding tables the percentages of organic matters removed in the process of filtration, as represented by the free ammonia, albuminoid ammonia and oxygen consumed, have been calculated and are presented in the following table. Tables are also appended showing, in a similar way, the purification effected in the six warmer months of the year, from June to November, inclusive, and in the six colder months, from December to May, inclusive.

Purification effected by the Sewage Filters at Westborough.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1900,	1.94	.5331	72.5	.41	.0969	76.4	2.82	.80	71.6
1901,	1.19	.4708	60.4	.59	.0622	89.5	4.24	.56	86.8
1902,	2.57	.4983	80.6	.79	.0683	91.4	5.03	.52	89.7
1903,	1.68	.6410	61.8	.54	.0849	84.3	3.55,	.73	79.4

Purification effected by the Sewage Filters at Westborough during the Summer Months (from June to November, inclusive) of Each Year.

1900,	2.24	.6173	72.4	0.50	.1244	75.1	3.42	1.04	69.6
1901,	1.35	.2979	77.9	0.33	.0542	83.6	2.81	0.49	82.6
1902,	3.25	.3160	90.3	0.69	.0657	90.5	4.20	0.54	87.1
1903,	2.13	.6913	67.5	0.44	.0962	78.1	2.88	0.72	75.0

Purification effected by the Sewage Filters at Westborough during the Winter Months (from December to May, inclusive) of Each Year.

1900,	1.66	.4846	70.8	0.32	.0703	78.0	2.19	0.55	74.9
1901,	1.12	.6270	44.0	0.47	.0707	85.0	4.03	0.64	84.1
1902,	1.74	.6657	61.7	1.35	.0709	94.7	8.02	0.49	93.9
1903,	1.09	.6573	39.7	0.64	.0702	89.0	4.17	0.73	82.5

The effluent from the Westborough filters is discharged in part into a trench and in part upon the ground near the filters, and quickly finds its way to the Assabet River.

The river above the point where it receives this effluent has a water-shed of 9.1 square miles. Below the filter beds the stream flows through extensive meadows for a distance of about 4.3 miles to the village of Northborough.

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Cost of the Works.

The amount paid for the land upon which the filters are situated was $1,000 and the filter beds cost $6,555. When the filtration area was reconstructed in 1900 a tract of land, which contained good gravel, was purchased, and the amount paid for this land, with some extra gravel obtained from another location, was $1,603. The total cost of the new filters, including this item, was $18,689, or about $4,672 per acre.

Cost of Maintenance of the Filters.

The annual cost of maintaining the filter beds appears to be about $500, exclusive of the salary of the superintendent of sewers, who is also superintendent of the water works and attends personally to the management of the filter beds. Crops are not grown upon these filter beds.

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Population in 1900, 118,421.

The city of Worcester is situated in the upper portion of the water-shed of the Blackstone River. The water-shed of the stream at a point near the lower end of the city has an area of about 70 square miles, which contains all of the thickly settled portions of the city.

A public water supply was introduced in 1845, and the supply is now taken by gravity from several small streams which are tributary to the Blackstone River above the city. The distributing mains have been extended throughout the built-up portions of the city, and practically the entire population is supplied with water from the public works. The average daily quantity of water used in 1903 was 9,688,000 gallons, which is equivalent to about 74 gallons per inhabitant.

Sewerage System.

The construction of a sewerage system in Worcester was begun in 1867, the sewers being designed to remove storm water as well as sewage. Mill Brook, one of the tributaries of the Blackstone River, which flows through the most thickly built-up sections of the city, was converted into a sewer by walling up and covering the channel, and practically all of the sewage of the city was formerly discharged into this channel. In 1890 works for the purification of a portion of the sewage by chemical precipitation were completed, and in 1893 the works were enlarged so that practically all of the dry weather flow of the sewage could be treated at the precipitation works, but at times of storms or of high flow in Mill Brook a large quantity of sewage was discharged with the storm water into Blackstone River.

In 1898 the construction of filter beds for the further purification of the sewage was begun, and the work of separating the sewage from the storm water by the construction of a separate system of sewers was begun at about the same time.

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At the present time all of the sewage from the separate system and the dry weather flow of the combined system of sewers is conveyed through a main sewer to the purification works, situated near the Blackstone River, a short distance above the Millbury line. The larger part of the sewage is mixed with chemicals, after which it flows through precipitation tanks, a portion of the effluent from the precipitation tanks being further treated by filtration through sand filter beds, but the larger portion being discharged into the river. The sewage which is not treated chemically is purified by filtration after passing through a settling tank.

At the end of the year 1903 there were 130.65 miles of sewers in the city, of which about 69 miles receive sewage only, while 61.65 miles receive both storm water and sewage. The number of buildings connected with the system is not known, but the population served by the system is estimated to be about 122,000.

Quantity of Sewage.

The quantity of sewage flowing depends chiefly upon the amount of surface and storm water flowing in the Mill Brook channel.

The following table gives the quantity of sewage treated at the purification works since 1899 and represents approximately the quantity of sewage flowing at times of dry weather. At times of wet weather the excess of flow is discharged directly into Blackstone River without treatment and no measurements are made of the quantity of sewage so discharged.

Quantity of Sewage treated per Month in Million Gallons per Day.

Month.	1899.	1900.	1901.	1902.	1903.
January,	18.0	12.7	4.56	10.38	17.84
February,	17.6	10.4	6.08	11.33	15.28
March,	15.4	11.3	7.90	15.97	19.12
April,	18.4	14.7	8.23	16.51	19.89
May,	17.0	15.3	12.02	13.77	14.54
June,	16.8	14.0	9.81	11.19	16.47
July,	15.3	13.2	13.99	10.00	15.19
August,	16.8	14.3	15.76	10.75	14.51
September,	17.3	14.6	10.11	10.76	13.07
October,	16.9	14.1	8.38	13.29	11.92
November,	15.9	12.9	8.66	14.20	11.68
December,	10.4	7.69	12.40	17.04	11.56

The sewage of the city of Worcester is unusual in its character owing to the large amount of manufacturing wastes contained in it, much of which is from iron works, where large quantities of acids are used, and the sew-

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age contains, consequently, a varying amount of iron sulphate and at times free acid. Large quantities of wastes from wool-scouring, dyeing, tanning and other manufacturing processes are discharged into the sewers. The character of the sewage is also influenced greatly by the amount of storm water with which it is mingled.

Description of Precipitation Works.

At the precipitation works the sewage is mixed with chemicals, after which it is discharged into the precipitation tanks. The chemical used is lime, which is added to the sewage in the form of milk of lime. The quantity of lime added to the sewage depends upon the character of the sewage, which is determined by chemical analysis of samples taken at frequent intervals.

The sulphate of iron in the sewage, together with the lime, form a satisfactory precipitant, but, as at times there is very little or no sulphate of iron present in the sewage, and the sewage flowing at such times is mixed with sewage containing the sulphate of iron which is stored for the purpose. In this way no other chemical is required except the lime.

The average quantity of lime used per million gallons of sewage treated each year since 1895 is given in the following table: —

YEAR.	Quantity of Lime per Million Gallons of Sewage (Pounds).	YEAR.	Quantity of Lime per Million Gallons of Sewage (Pounds).
1895,	1,030	1900,	1,230
1896,	1,212	1901,	1,498
1897,	1,130	1902,	1,005
1898,	1,073	1903,	871
1899,	1,204		

After the lime is added the sewage flows to the tanks through a mixing channel, which is an open channel, on the sides of which obstructions are placed which throw the sewage from one side of the channel to the other, thus insuring the complete mixing of the lime with the sewage.

There are 16 settling tanks in use, 6 of which are 100 feet long, 66⅔ feet wide and 7 feet deep, and 10 are 166⅔ feet long, 40 feet wide and 7 feet deep.

The total capacity of the settling tanks is about 5.5 million gallons. One of the tanks is reserved as a sedimentation tank for the sewage which is discharged upon the filter beds without chemical treatment, so that only 15 of the tanks are used for the chemically treated sewage. The sewage is ordinarily passed through all of the tanks except those which are being cleaned, and with the ordinary flow the sewage is about 8 hours in passing through the tanks.

The tanks in which the sewage is first discharged collect a large proportion of the solid matter. The depth of the sludge in these tanks when they are cleaned averages about 2.5 feet, and this material is removed about once in two weeks. The tanks through which the sewage subsequently passes do not collect as much solid matter and are cleaned out only about once a month, the depth of sludge being about 1.5 feet when they are cleaned.

When the tanks are cleaned the supernatant liquid is first drawn off and then the sludge is pumped by means of Shone ejectors to storage basins, where it is allowed to settle and the supernatant liquid from this tank is drawn off. The remaining sludge is then conveyed to filter presses, where a further amount of the liquid is removed. The sludge cakes formed by the filter presses are removed in cars by a special line of electric railroad to a point in the valley of the river about three-quarters of a mile below the works, and a very small amount is taken away and used as a fertilizer. During the year 1903, 25,000,000 gallons of sludge were pumped to the storage basins and 700,000 gallons of supernatant liquid were drawn from these basins, leaving 24,300,000 gallons of sludge, which was pressed into cake. This amount of sludge made 29,604 cubic yards of the compressed cake, equivalent to about 25,000 tons.

Description of Filter Beds.

Below the precipitation works 23 filter beds have been constructed, containing an area of about 23.2 acres. These filter beds are constructed of coarse sand, all of which was obtained from an adjacent knoll. The beds are underdrained by lines of pipe 50 feet apart, laid from 4 to 6 feet beneath the surface.

The sewage is applied to the beds in various ways, in some cases being discharged into a small basin formed of concrete, in the same manner as at Clinton (described on page 333), and in some cases discharged through carriers laid across the centre of each bed, similar to those used at Brockton (described on page 321).

The filter beds have been used to some extent for experimental purposes, and different kinds of sewage have been applied to them. During the past year nine acres of filter beds received sewage which had been passed through one of the settling tanks without the addition of chemicals and 13 acres have been used for the purification of the effluent from chemical precipitation. The untreated sewage was passed through the settling tank at the rate of from fifteen to twenty million gallons per day and with this rate the sewage was half an hour in passing through the tank. The beds received doses which were regulated according to the condition of the beds, varying from 125,000 to 600,000 gallons six times each week when the beds were in good condition, but after a bed became clogged it was dosed only about every other day, with frequent periods of rest for a few days.

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The beds which receive the chemical effluent or well-settled sewage are cleaned about once each year. In winter the beds are operated in much the same way as in summer, and there is no special preparation of the surface, but during the coldest weather care is taken not to permit the beds to become deeply frozen between the doses of sewage.

Analyses of samples of sewage and effluent are made regularly by the chemist at the works, and from the printed results of these analyses the following tables have been prepared, showing the average yearly purification effected by chemical precipitation alone, by the filtration of the chemical effluent and by the filtration of the raw sewage after sedimentation: —

Purification effected by Chemical Precipitation.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.	Sewage.	Effluent.	Per Cent. Removed.
1895,	1.160	1.008	13.02	.518	.252	51.63	5.27	2.40	54.35
1896,	1.118	1.012	9.48	.497	.229	53.92	4.63	2.23	51.62
1897,	1.108	1.001	9.66	.478	.224	53.02	4.23	2.03	52.00
1898,	0.851	0.775	8.93	.438	.211	51.82	4.03	2.06	48.89
1899,	1.097	0.988	9.93	.480	.222	53.73	5.63	2.71	51.73
1900,	1.292	1.137	11.99	.551	.258	53.18	7.18	3.65	49.17
1901,	1.718	1.501	12.63	.624	.295	52.72	8.76	4.52	48.41
1902,	2.020	1.862	7.82	.764	.426	44.22	10.40	4.68	54.98
1903,	1.761	1.551	11.92	.834	.403	51.69	9.26	4.40	52.50

Purification effected by Filtration of the Effluent from Chemical Precipitation.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Filtrate.	Per Cent. Removed.	Sewage.	Filtrate.	Per Cent. Removed.	Sewage.	Filtrate.	Per Cent. Removed.
1901,*	1.626	1.006	38.14	.318	.079	74.15	4.10	0.90	78.13
1902,	2.320	1.082	53.35	.524	.083	84.16	6.90	0.76	89.00

Purification effected by Filtration of Raw Sewage after Sedimentation.

1900,	1.624	1.892	-16.50	.447	.065	85.47	6.32	1.17	81.49
1901,	2.470	2.032	17.73	.523	.128	75.53	8.02	1.32	83.54

* April to September, inclusive.

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The effluent from chemical precipitation and from the filter beds is discharged into the Blackstone River. The effect of the discharge of effluent from these works into the river, together with the effect of discharging mingled sewage and storm water into the stream at times of storms and melting snow, is shown in the tables of analyses on page 204 of this volume.

Cost of the Works.

The total cost of the precipitation works was $265,628, and the cost of the filtration area was $125,530, making the total cost of the works $391,158.

The cost of maintaining the precipitation works during 1903 was $46,830 of which $25,767 was for the disposal of sludge. During this year 5,251,-000,000 gallons of sewage were treated, making the total cost of treatment $8.91 per million gallons of sewage treated.

The cost of maintaining the filtration area has been about $7,062 during the year 1903. From 1899 to 1903 inclusive 4,174,000,000 gallons of sewage have been treated, at a total cost per million gallons filtered of about $6.79.

SUMMARY.

The information relative to the population of the various cities and towns having sewage purification works, the extent of the sewerage systems, etc., is summarized in the following table: —

City or Town.		Population, 1903.	Population connected with Sewers.	Number of Sewer Connections.	Population connected per Connection.	Length of Sewers (Miles).	Population connected per Mile of Sewer.
Andover,		7,214	3,600	431	8	10.7	336
Brockton,		44,202	25,000	1,714	15	32.6	767
Clinton,		14,969	10,000	1,486	7	19.2	521
Concord,		5,938	1,200	238	5	7.5	160
Framingham,		12,876	7,500	1,214	6	15.7	478
Gardner,	Gardner system,	11,792	3,500	277	13	8.0	437
	Templeton system,		4,500	350	13	7.4	608
Hopedale,		2,513	2,000	200	10	4.0	500
Leicester,		3,522	500	70	7	2.1	238
Marlborough,		12,788	10,000	1,592	6	24.2	413
Natick,		9,892	4,000	634	6	10.8	370
Pittsfield,		22,549	15,000	1,827	8	31.7	473
Southbridge,		11,090	2,200	316	7	5.7	386
Spencer,		7,635	3,000	600	5	10.0	300
Stockbridge,		2,083	800	107	7	3.5	229
Westborough,		5,499	3,000	280	11	7.2	417
Worcester,		130,214	122,000	-	-	130.6	934

The following table gives a summary of the maximum and minimum flows of sewage, the flows per inhabitant, per sewer connection, per mile of sewer, etc.: —

City or Town.	Average Yearly Quantity of Sewage.					Average Quantity of Sewage in Maximum Month.				
	Gallons per 24 Hours.	Gallons per 24 Hours.				Gallons per 24 Hours.	Gallons per 24 Hours.			
		Per Inhabitant.	Per Person Connected.	Per Connection.	Per Mile of Sewer.		Per Inhabitant.	Per Person Connected.	Per Connection.	Per Mile of Sewer.
Andover,	125,000	17	35	290	11,600	-	-	-	-	-
Brockton,	878,000	20	35	512	26,930	1,369,000	81	55	799	41,990
Clinton,	785,000	52	78	528	40,900	1,170,000	78	117	787	60,940
Concord,	312,000	53	260	1,311	41,430	455,000	77	379	1,912	60,420
Framingham,	652,000	53	87	537	41,400	967,000	78	129	796	61,400
Gardner, Gardner system,	302,000	47	86	1,090	37,750	563,000	-	161	2,032	70,875
Gardner, Templeton system,	250,000		56	714	33,780	-	-	-	-	-
Hopedale,	150,000	60	75	750	37,500	-	-	-	-	-
Leicester,	30,000	9	60	429	14,020	-	-	-	-	-
Marlborough,	1,100,000	86	110	691	45,450	2,028,000	159	203	1,274	83,800
Natick,	566,000	57	142	893	52,400	1,119,000	113	280	1,765	103,510
Pittsfield,	1,456,000	65	97	797	45,930	1,561,000	69	104	854	49,240
Southbridge,	350,000	32	159	1,108	61,400	-	-	-	-	-
Spencer,	375,000	49	125	625	37,500	-	-	-	-	-
Stockbridge,	75,000	36	94	700	21,430	-	-	-	-	-
Westborough,	282,000	51	94	1,007	38,900	571,000	104	190	2,039	78,760

City or Town.	Quantity of Sewage on Maximum Day.					Per Cent. which Average for Maximum Month is of Average for Year.	Per Cent. which Maximum Day is of Average for Year.	Average Quantity of Sewage in Minimum Month.					Excess of Flow during Maximum Month over Flow during Minimum Month (Gallons per 24 Hours).	Excess per Mile of Sewer (Gallons per 24 Hours).
	Gallons per 24 Hours.	Gallons per 24 Hours.						Gallons per 24 Hours.	Gallons per 24 Hours.					
		Per Inhabitant.	Per Person Connected.	Per Connection.	Per Mile of Sewer.				Per Inhabitant.	Per Person Connected.	Per Connection.	Per Mile of Sewer.		
Andover,	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Brockton,	1,677,000	38	67	978	51,440	156	191	659,000	16	28	402	21,130	680,000	20,860
Clinton,	1,632,000	109	163	1,098	85,000	149	208	546,000	37	55	367	28,440	624,000	32,500
Concord,	742,000	125	618	3,118	98,540	146	238	201,000	34	167	845	26,690	254,000	33,730
Framingham,	1,840,000	149	245	1,514	116,800	148	282	476,000	38	63	392	30,220	491,000	31,180
Gardner, Gardner system,	832,000	-	238	3,000	104,000	186	275	196,000	-	56	708	24,500	367,000	45,875
Gardner, Templeton system,	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hopedale,	400,000	159	200	2,000	100,000	-	267	-	-	-	-	-	-	-
Leicester,	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Marlborough,	3,540,000	277	354	2,224	146,280	184	322	587,000	46	59	369	24,260	1,441,000	59,540
Natick,	1,792,000	181	448	2,826	165,800	198	317	282,000	29	70	445	26,090	837,000	77,420
Pittsfield,	2,761,000	122	184	1,511	87,100	107	190	1,268,000	56	85	694	40,000	293,000	9,240
Southbridge,	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spencer,	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stockbridge,	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Westborough,	800,000	145	267	2,857	110,310	202	284	131,000	24	44	468	18,070	440,000	60,690

The last two columns in the above table indicate in a general way the quantity of leakage of ground water into the sewers during the month of maximum leakage.

The area of intermittent filter beds at the various places and the quantity of sewage treated in 1903 are summarized in the following table: —

City or Town.	Area of Filter Beds (Acres).	Quantity of Sewage treated during 1903 (Gallons per Day).					
		Average for Year.		Average for Maximum Month.		Maximum Day of Year.	
		Total.	Per Acre.	Total.	Per Acre.	Total.	Per Acre.
Andover,	3.65	125,000	34,200	-	-	-	-
Brockton,	21.48	878,000	40,900	1,369,000	63,700	1,677,000	78,000
Clinton,	23.50	785,000	33,400	1,170,000	49,800	1,632,000	69,400
Concord,	3.30	312,000	94,500	455,000	137,900	742,000	224,800
Framingham,	19.90	652,000	32,800	967,000	48,600	1,840,000	92,500
Gardner (Gardner system),	2.50	302,000	120,800	563,000	225,200	832,000	332,800
Gardner (Templeton system),	2.25	250,000	111,100	-	-	-	-
Hopedale,	2.30	150,000	65,200	-	-	400,000	173,900
Leicester,	0.36	30,000	83,300	-	-	-	-
Marlborough,	11.20	1,100,000	98,200	2,028,000	181,100	3,540,000	316,100
Natick,	11.10	566,000	51,000	1,119,000	100,800	1,792,000	161,400
Pittsfield,	21.67	1,456,000	67,200	1,561,000	72,000	2,761,000	127,400
Southbridge,	7.25	350,000	48,300	-	-	-	-
Spencer,	9.30	375,000	40,300	-	-	-	-
Stockbridge,	{1.00 / 2.60}	75,000	20,800	-	-	-	-
Westborough,	4.00	282,000	70,500	571,000	142,700	800,000	200,000

Efficiency of the Filters.

The object of the construction of the purification works at the places described has been the prevention of the pollution of inland streams and water courses. In no case are the effluents discharged into a stream used subsequently as a source of public water supply, but a high degree of purification of the sewage is necessary at nearly all of the places described in order to prevent objectionable conditions in the streams into which the effluents are discharged.

The purification effected varies considerably at the different filtration areas, and in different seasons of the year, but in no case has the effluent caused trouble when discharged into a stream. The worst effluent is generally produced during the spring, when the surfaces of the beds are clogged, and at this time there is a large flow in the streams, so that the imperfectly purified effluent has little effect upon the water. Experience has shown that if the sewage is all passed through sand filters having a depth of at least 4 feet, the sewage will be sufficiently purified to cause no

further trouble when discharged into a stream. The only noticeable effect of the imperfectly purified effluent is a slight odor in the immediate vicinity of the outlet and the presence of some iron in the water. Where objectionable conditions have occurred at a purification works they have been caused by the discharge of sewage into the stream without treatment rather than by imperfect purification.

The character of the sewage delivered at the various filtration areas in the year 1903, as shown by averages of analyses of monthly samples, is given in the following table in which the places have been arranged in the order of the quantity of albuminoid ammonia present in the sewage: —

[Parts per 100,000.]

City or Town.	Residue on Evaporation.						Ammonia.				Chlorine.	Oxygen Consumed.	
	Total Residue.			Loss on Ignition.			Free.	Albuminoid.				Unfiltered.	Filtered.
	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.		Total.	Dis-solved	Sus-pended			
1903.													
Concord,	20.29	17.27	3.02	8.44	5.71	2.73	0.69	0.17	0.10	0.07	2.66	1.36	0.82
Stockbridge,	23.56	19.51	4.05	8.80	5.71	3.09	1.19	0.20	0.11	0.09	1.28	1.52	0.96
Natick,	36.13	30.58	5.55	13.65	9.09	4.56	1.48	0.32	0.17	0.15	5.95	3.27	2.25
Hopedale,	19.67	14.57	5.10	10.43	6.09	4.34	2.22	0.34	0.22	0.12	2.23	2.98	2.07
Southbridge,	28.71	17.61	11.10	15.97	7.31	8.66	1.95	0.43	0.25	0.18	2.90	4.01	2.51
Leicester,	42.17	28.16	14.01	22.05	10.32	11.73	2.67	0.50	0.24	0.26	5.47	5.08	3.03
Marlborough,	44.82	31.07	13.75	21.89	10.32	11.57	3.15	0.54	0.27	0.27	5.90	4.44	2.50
Westborough,	37.01	18.68	18.33	21.30	7.61	13.69	1.68	0.54	0.21	0.33	2.37	3.55	1.50
Spencer,	35.78	24.34	11.44	20.22	10.06	10.16	1.81	0.55	0.31	0.24	3.99	4.65	2.74
Gardner (Gardner system),	38.37	22.97	15.40	22.93	9.89	13.04	2.45	0.60	0.35	0.25	3.38	4.92	2.82
Andover,	46.65	36.32	10.33	24.39	15.77	8.62	4.82	0.68	0.41	0.27	7.00	4.90	3.33
Framingham,	58.77	37.53	21.24	29.88	13.66	16.22	3.17	0.79	0.41	0.38	6.99	4.73	2.73
Gardner (Templeton system),	43.06	22.88	20.18	26.97	9.21	17.76	3.31	0.80	0.38	0.42	4.38	6.03	2.61
Clinton,	94.94	72.75	22.19	47.84	32.34	15.50	4.04	0.96	0.68	0.28	5.95	11.37	8.76
Pittsfield,	90.98	42.31	48.67	55.75	18.89	36.86	1.46	0.99	0.23	0.76	2.57	7.92	1.97
Brockton,	121.00	63.10	57.90	75.80	25.40	50.40	5.32	1.57	0.51	1.06	13.27	21.85	9.30

The character of the effluent discharged from the various works during the year 1903, as shown by the average of monthly chemical analyses, is summarized in the following table, in which the places have been arranged in the order of the average quantity of albuminoid ammonia present in the effluent during the year. The quantity of sewage treated per acre is also given.

[Parts per 100,000.]

City or Town.	Quantity of Sewage treated per Acre per Day (Gallons).	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
1903.										
Concord,	94,500	17.56	0.0017	.0104	2.59	0.8467	.0000	0.11	5.1	0.0041
Brockton,	40,900	53.17	0.2250	.0166	11.13	3.0750	.0103	0.53	3.6	0.0601
Spencer,	40,300	17.95	0.1484	.0186	3.16	0.3691	.0248	0.33	6.1	0.3542
Framingham,	32,800	28.51	0.2169	.0186	5.17	0.9854	.0151	0.26	6.4	0.0361
Stockbridge,	37,500	19.95	0.0990	.0207	1.81	0.1630	.0025	0.30	9.8	0.1288
Natick,	51,000	20.62	0.6150	.0319	4.04	0.2217	.0195	0.44	5.8	0.2290
Pittsfield,	67,200	33.38	0.2626	.0365	2.29	0.6674	.0198	0.38	13.1	0.0266
Southbridge,	48,300	10.96	0.3865	.0369	1.74	0.2036	.0126	0.36	3.1	0.1039
Marlborough,	99,800	27.05	1.2365	.0622	5.97	0.3521	.0272	0.73	6.3	0.3016
Andover,	34,200	26.07	1.1040	.0677	5.37	0.8325	.0161	0.74	4.8	0.3097
Gardner (Templeton system),	134,200	25.69	0.7761	.0698	3.04	1.5180	.0196	0.58	5.8	0.0397
Clinton,	33,400	41.66	1.0173	.0774	5.55	0.4399	.0199	1.12	6.4	1.1992
Leicester,	55,600	23.67	0.7065	.0813	3.94	0.9117	.0367	0.96	4.7	0.0981
Gardner (Gardner system),	120,800	23.48	1.7990	.0841	3.02	0.0442	.0047	1.07	6.1	1.3567
Westborough,	70,500	15.54	0.6410	.0849	2.22	0.3571	.0528	0.73	3.8	0.0469
Hopedale,	65,200	23.39	1.0440	.0888	2.49	1.5866	.0256	0.72	5.3	0.0214

The purification effected in 1903 at the different places in the foregoing table is shown by the following table, in which the places are arranged in the order of the percentage of albuminoid ammonia removed: —

Purification effected.

Place.	Free Ammonia (Per Cent. Removed).	Albuminoid Ammonia (Per Cent. Removed).	Oxygen Consumed (Per Cent. Removed).
Brockton,	95.8	98.9	98.5
Framingham,	93.2	97.6	94.4
Spencer,	91.8	96.6	92.9
Pittsfield,	82.0	96.3	95.2
Concord,	99.8	93.9	91.9
Clinton,	74.8	91.9	90.1
Southbridge,	80.2	91.4	91.0
Gardner (Templeton system),	76.6	91.3	90.4
Natick,	58.4	90.0	86.5
Andover,	77.1	90.0	84.9
Stockbridge,	91.6	89.6	79.9
Marlborough,	60.7	88.5	83.6
Gardner (Gardner system),	26.6	86.0	78.3
Westborough,	61.8	84.3	79.4
Leicester,	73.5	83.8	81.1
Hopedale,	53.0	73.9	75.8

Of the sixteen places included in the table showing the average quality of the effluent, the quantity of albuminoid ammonia in the effluent from

the first eight is less than .04 of a part per 100,000, while in the places included in the last half of the table it ranges from .06 to .09 of a part per 100,000. The least satisfactory effluent discharged from any of the works in 1903 was that from the filters at Hopedale. The village is small, and no manufacturing wastes are discharged into the sewers. The filters are similar to those of other places both in quality of material and method of construction, and the quantity of sewage applied per acre is but little greater than the average applied to other similar filters. The only important respect in which the method of operation of the Hopedale works differs from that of most of the others is that the sewage is first treated in a septic tank before being passed to the filters. The changes which take place in the condition of the sewage in this tank are apparently unfavorable to its subsequent thorough purification when applied directly to sand filters operated intermittently. A similar condition has been observed in the operation of experimental filters at Andover and Lawrence, the results of which are described elsewhere in this report, and in previous reports of the Board.

Next to Hopedale, the effluents of poorest quality have been found during the year at Westborough, Gardner (Gardner area) and Leicester. The poor quality of the Westborough effluent is undoubtedly due very largely to the uneven distribution of the sewage upon the filter beds, — it having been observed that the sewage is allowed to flow continuously upon one portion of the beds for periods of many days. If the sewage should be applied evenly and intermittently to the filter beds there is no doubt that a much better effluent would result. At the Gardner filters the conditions are similar to those at Westborough in that the sewage runs upon the beds continuously for periods of many weeks, and no opportunity is given for air to enter the filters. In this case, however, there is no doubt that the quantity of sewage applied, which amounted on an average to about 120,000 gallons per acre per day in 1903, is beyond the capacity of the filters, and that if the amount applied should be reduced and the filters operated intermittently, a better effluent would be secured. The need of improvement in the conditions about this area has been recognized, and provision is being made for diverting the excess of sewage to another area.

At Leicester the conditions resemble somewhat those at Hopedale in that the sewage is passed through a tank of large capacity in proportion to the flow of sewage before being applied to the filters; and as this tank is rarely emptied, it operates much of the time as a septic tank.

The sewage applied to the filters at Clinton is exceedingly strong, and while the percentage of organic matters removed from the sewage is higher than at the majority of the places examined, the effluent discharged from this area is of poorer quality than the average. The reason for this is doubtless to be found in the character of the sewage, which contains a large quantity of fat from wool-scouring waste, which collects upon the surfaces

of the filters and probably prevents access of air. The poor quality of the effluent is doubtless also due in part to the large doses of sewage applied to the filters, though the average quantity applied is not excessive. Changes are being made in this system with a view to the removal of a part of the suspended matter and grease from the sewage before it is discharged upon the filters.

The effluent from the Gardner filter beds at Templeton has been of less satisfactory quality during the year than from a majority of the works. In the design of this area it was intended that a portion of the solid matter should be removed from the sewage by the use of strainers, but during much of the year the sewage has been applied directly to the filter beds, and the character of the sewage which they have been required to care for has differed materially from that for which they were designed.

The sewage applied to the filter beds at Andover is greatly decomposed and resembles in condition that applied to the filters of Hopedale and Leicester. A better effluent would doubtless be obtained if the sewage were fresher.

The best effluents, all things considered, have been obtained at Brockton, Spencer and Framingham, where the effluents have been practically always clear, colorless and odorless, though occasionally a small quantity of iron gives the effluent a rusty appearance. At Concord and Stockbridge, also, excellent effluents are obtained, though the quality of the former as shown by the analyses presented is doubtless somewhat better than would be the case if drawn from underdrains beneath the filters. The sewage applied at both places is weak. At all of these places the sewage is applied directly to the filters without previous treatment, and the sludge accumulating upon the surfaces of the filters is removed when dry.

The experience of the past fifteen years in the operation of intermittent filters has shown that it is best to avoid preliminary treatment of the sewage when a sufficient area of good soil is available for filter beds. The sewage can be treated more economically, and otherwise more satisfactorily, and better results can be obtained, when all of the sewage is discharged directly upon the filter beds. The solid matter which accumulates on the surfaces of the beds can be raked off readily, and this is the easiest means of disposing of this matter. By this method it has been found practicable to dispose of quantities of sewage varying from 50,000 to more than 100,000 gallons per acre per day, — the quantity depending chiefly upon the strength of the sewage and the character of the filtering material.

In order to dispose of larger quantities upon a given area it becomes necessary to remove a portion of the suspended matter from the sewage, and several methods of removal of this matter are in use at the different areas, which include the removal of suspended matter by sedimentation, by use of the septic tank, by chemical precipitation and by straining through coarse material at a rapid rate.

At places where the sewage is collected in a storage reservoir and pumped during the daytime to a filtration area there is a marked variation in the character of the sewage at different times in the day, owing to the sedimentation which takes place in the reservoir. Advantage has been taken of this fact at Brockton and Pittsfield, where the heavier sewage is discharged upon filters which are used for this purpose alone. The solid matters which tend to collect upon the surfaces of the filter beds are in this way concentrated upon a few beds, the surfaces of which are cleaned when necessary, while the surfaces of the filters in the remaining portion of the area require little attention. The filters used to receive the heavier sewage at Brockton, for example, are cleaned after receiving about twenty-three doses, while the remaining filters are rarely cleaned more than once a year.

More thorough removal of suspended matter can be effected, however, by the use of regular settling tanks, and settling tanks for this purpose are now in use in several of the areas, notably at Marlborough and Gardner, where, however, owing to the increase in quantity of sewage since the settling tanks were installed, the period of sedimentation is now quite limited, so that the effect is probably no greater than is obtained in the sewage reservoirs. The use of settling tanks is chiefly of value in preventing the clogging of the beds at times when they cannot be cleaned on account of the presence of ice and snow on the surfaces of the beds. The heavy sewage from settling tanks can be disposed of on sludge beds prepared in the same manner as filter beds, where it can be allowed to dry. When dried, sludge may have some value as a fertilizer, and is readily disposed of.

The only illustration of the use of a tank designed to be used as a septic tank in connection with a filtration area is at Hopedale, where the results thus far obtained have been unsatisfactory, both on account of the filling of the tank with solid matter from the sewage and the poor quality of the effluent discharged from the filters.

The removal of sludge by chemical precipitation is illustrated on a large scale at Worcester, where about nine-tenths of the suspended matter is removed from the sewage in the precipitation tanks, and a little more than half of the total organic matter. The removal of sludge by straining is practised at the Templeton area at Gardner, where it has been practicable to apply much larger quantities of sewage to the filters after straining out the organic matter than has been found practicable at any of the other areas. During the short time that these works have been in operation the strainers have not been operated regularly, however, and the effluent from these filters has been less satisfactory than from many of the others.

The following tables give a summary of the cost of disposal works, and the cost of maintenance in the year 1903, from the most reliable data available: —

Cost of Purification Works.

City or Town.	Area of Filter Beds (Acres).	Cost of Filter Beds.	Cost per Acre.	Total Cost of Purification Works.
Andover,	3.8	$17,649	$4,644	$22,157
Brockton,	21.48	50,302	2,342	208,977
Clinton,	23.5	21,163	900	104,673
Concord,	3.3	2,600	788	48,845
Framingham,	19.9	10,000	503	76,495
Gardner (Gardner system),	2.67	18,850	7,060	24,799
Gardner (Templeton system),	2.25	11,253	5,001	36,898
Leicester,	0.36	2,389	6,636	-
Marlborough,	11.92	31,517*	2,644*	34,517
Natick,	11.1	23,500	2,117	87,000
Pittsfield,	24.78	30,000	1,211	155,500
Southbridge,	7.25	7,632	1,053	12,632
Spencer,	9.3	8,273	890	11,630
Stockbridge,	3.6	8,238*	2,288*	9,738
Westborough,	4.0	18,689	4,672	-
Worcester,	23.2	125,530	5,411	391,158

* Including cost of tank.

Cost of Maintaining Purification Works.

City or Town.	Area of Filter Beds (Acres).	Quantity of Sewage treated (Gallons per Day).	Cost of maintaining Filter Beds.	Cost per Acre.	Cost per Million Gallons Sewage treated.
Andover,	3.8	125,000	$638	$168	13.98
Brockton,	21.48	878,000	3,538	165	11.04
Clinton,	23.5	785,000	2,235	95	7.80
Concord,	3.3	312,000	327	99	2.87
Framingham,	19.9	652,000	-	-	-
Gardner (Gardner system),	2.67	302,000	1,070	401	9.71
Gardner (Templeton system,	2.25	250,000	849	377	9.30
Leicester,	0.36	30,000	125	347	11.42
Marlborough,	11.92	1,100,000	1,043	87	2.60
Natick,	11.1	566,000	125	11	0.61
Pittsfield,	24.78	1,456,000	1,300	52	2.45
Southbridge,	7.25	350,000	500	69	3.91
Spencer,	9.3	375,000	800	86	5.84
Stockbridge,	3.6	75,000	600	167	21.92
Westborough,	4.0	282,000	500	125	4.86
Worcester,	23.2	2,287,000*	-	-	6.79*

* Average for five years, from 1899 to 1903 inclusive.

Permanency of the Filters.

In the foregoing descriptions of the results of filtration at the various works tables have been given showing the average yearly analyses of the effluents for periods of several years, and an examination of the results shows that in some cases — notably at Marlborough and Gardner — there has been quite a constant deterioration in the character of the effluent, while on the other hand, at Framingham, the works which have been the longest in operation, no marked signs of deterioration in the character of the effluent are apparent up to the present time.

The filter beds at Marlborough and Gardner have been overworked for several years and operated in such a manner as to tend to clog them, while at Framingham the filters have been operated with care, sewage has been applied intermittently, and ample opportunity has been afforded for air to enter the filters.

At Brockton a deterioration is shown by the analyses of 1903, though previous to that time little change is noticeable. In 1903 it became evident that the quantity of sewage delivered at the Brockton filtration area was larger than could be cared for properly, and steps were taken early in 1904 to enlarge the filters. At the other places examined no regular change in the quality of the effluent is shown by the analyses.

The results on the whole show that slight deterioration is taking place in those filters which are overdosed and is due to the clogging of the surface sand with organic matters, especially fats. If this condition should continue the time may come when it will be necessary to remove a few inches of sand from the surfaces of these filters. It is not certain, however, that such removal would be necessary, especially if overdosing should be discontinued.

Pollution of Streams by Cities and Towns having Purification Works.

At Concord, Framingham, Leicester, Stockbridge and Westborough all of the sewage discharged into the town sewers during the year has been delivered at the purification works and treated before being discharged into the streams. At Brockton and Clinton very small quantities have been occasionally allowed to flow into the streams near which the pumping stations are situated, such discharge taking place chiefly in the winter and spring.

At Andover the greater portion of the sewage is conveyed to the filtration area by gravity, and all of the sewage collected in the gravity system is applied to the filter beds, the effluent from which, after flowing through a small brook, finds its way into the Shawsheen River. The sewage from the lower portion of the main village, which cannot be discharged at the filtration area by gravity, is brought to a pumping station, whence it is provided, in the plans of the works, to pump the sewage into the main

gravity sewer; but during practically all of the time in 1903 the sewage from this portion of Andover has been allowed to flow directly into the river in order to avoid the expense of pumping. This sewage pollutes the stream considerably in the neighborhood of the outlet, and its effect is especially noticeable in the drier portion of the year.

The original Gardner filter beds are inadequate for the purification of all of the sewage discharged there, and much of the sewage has been allowed to flow directly into Pond Brook, a tributary of the Otter River, after passing over the surfaces of several of the filter beds. The brook has been grossly polluted by this sewage, but the construction of works for conveying a portion of the sewage now delivered at this area to the new filtration area in Templeton was begun early in 1904. All of the sewage conveyed to the new filtration area in Templeton has been passed through the filters, the effluent being discharged into ditches through which it flows to the Otter River.

At Hopedale, where the sewage is received in a large reservoir or tank, operated as a septic tank, the tank became filled with solid matter, which was removed with great difficulty and much sewage has been discharged directly into Mill River during the cleaning of this tank. The filter beds at this area are considerably overworked at times.

The quantity of sewage discharged at the Marlborough filtration area in certain seasons of the year, especially in the winter and spring, is greatly in excess of the capacity of the filters to receive and purify it, and much of the sewage is discharged directly into a small local water course, which is grossly polluted thereby. A large addition to this filtration area is necessary in order to properly purify the sewage and prevent the pollution of the neighboring stream.

All of the sewage of the town of Natick is pumped to the filtration area, but the capacity of the filters is insufficient for the passage of all of the sewage in the winter and spring, when the flow is greatly increased by leakage into the sewers, and during the past year much sewage has been discharged upon the ground adjacent to Bannister Brook, resulting in the serious pollution of the stream. The area owned by the town is ample for the purification of all the sewage, and additional filter beds could be constructed adjacent to those now in use.

At Pittsfield a considerable quantity of sewage has, during the past year, been allowed to flow into the west branch of the Housatonic River through a sewer not yet connected with the main system delivering sewage at the pumping station. Sewage has also been occasionally wasted in other ways, but, aside from the outlet into the west branch of the Housatonic River, the quantity discharged in an unpurified state has been very small.

During a portion of the year the sewage was allowed to escape from the lower filter beds at Southbridge directly into the Quinebaug River, on the banks of which the filters are situated. It is probable that by levelling

the filters and the exercise of proper care in distribution the sewage could be purified on this area, though considerable storm water finds its way into the sewers in this town, greatly increasing the flow at times of wet weather. The quantity of sewage allowed to discharge into the Quinebaug River has been large in the wetter portion of the year, but very little has escaped during the drier portion.

The only sewage discharged without treatment from the Spencer system has been that which has been allowed to overflow on account of the clogging of the screens at the head of the inverted siphon, or that which is caused by the discharge of sewage into the river while the filter beds are being cleaned. The Spencer filter beds are amply capable of purifying all of the sewage discharged from the sewers of the town, and it is unnecessary to allow any of it to flow into the streams without purification.

The sewers of Worcester were originally constructed upon the combined plan, receiving both sewage and storm water, and the channel of Mill brook was formerly used as the main sewer of the city. Large expenditures have been made in order to separate the sewage from the storm water, and much of this work has been completed. The area of filter beds has been increased during the year 1903 making the total area of filter beds about 23.2 acres. All of the sewage discharged at the precipitation works is treated with chemicals. A portion of it is then passed through the filters and the remainder discharged directly into the Blackstone River. The condition of this stream has been described in previous reports and has undergone no important change.

FOOD AND DRUG INSPECTION.

FOOD AND DRUG INSPECTION.

The work of food and drug inspection, which has been conducted continuously by the Board since 1883, has undoubtedly secured to the people of the State a degree of protection from fraudulent and harmful adulteration which, as measured by an economic standard, is greatly in excess of the cost of administering the laws providing for this important work.

The operations conducted under these laws embrace the following points: —

1. *Provision of Laboratories for the Examination of Samples of Food and Drugs collected.* — During the first eight years after the work of inspection was begun, the analysis was conducted by different chemists in their own private laboratories. On Oct. 1, 1891, the entire work, except a small portion embracing the collection and analysis of milk in western Massachusetts, was reorganized and placed under the charge of one chemist, a laboratory having been established at 994 Washington Street, Boston, where this work was conducted until the completion of the addition to the State House in 1895, when all of the work of analysis conducted in Boston was concentrated by removal to the new laboratories on the fifth floor of the State House annex. By this measure a much larger amount of work has been accomplished, the entire time of two analysts being now devoted to this line of work. The laboratories are of ample size and are provided with the best facilities for carrying out the operations of this department.

2. *Collection of Samples.* — This part of the work is carried out by three collectors, who visit the different cities and towns and obtain by purchase samples of food and drugs in sufficient quantity for the purposes of inspection and analysis. Years of experience in this line of work have enabled these collectors to select such articles as are liable to adulteration, since many of the most important articles of the food supply are practically exempt from adulteration.

These collectors, or inspectors, are required to keep records of each sample, which include the following items: —

(*a*) The inspector's number.

(*b*) The date of purchase, or receipt of sample.

(*c*) The character of the sample.

(*d*) The name of the vendor.

(*e*) The name of the city or town, and street and number, where the sample is obtained, and in the case of a licensed milk peddler, the number of his license.

(*f*) As far as possible the names of manufacturers, producers or wholesalers, with marks, brands or labels stamped or printed upon goods.

The samples intended for analysis are obtained in open market, at groceries, provision stores, factories, peddlers' wagons, dairies, drug stores, wholesale or retail, or any other places where food or drugs are sold or offered for sale. They are then taken to the laboratory and delivered to the analysts, after the brands, labels or other marks which indicate their source have been removed, the inspector being forbidden to convey any information to the analyst as to the source of the samples thus obtained.

If any article is found to be adulterated, a portion is reserved and sealed, and in case of a trial at court the portion thus reserved may be delivered to the defendant, or to his attorney.

Provision is also made for receiving articles direct from the consumer, in cases where adulteration is suspected. For this purpose a record is kept at the office of all such samples as are brought to the State House by consumers for examination. After many years' experience, however, it is found that the majority of such articles prove to be genuine, since the popular notion as to the character of food adulteration is usually incorrect.

In case of a perishable article, like milk, provision is made for the delivery of a portion of the sample to the vendor at the time of taking it, and after it has been sealed by the inspector.

3. *Analysis of Samples.* — It is the duty of the analysts to examine all articles submitted to them, and to determine by such examination whether such articles, manufactured for sale, offered for sale, or sold in the Commonwealth, are adulterated within the meaning of section 18, chapter 75 of the Revised Laws. (See Rules and Regulations of the Board, Manual of Health Laws, p. 130.) The results of their work are reported to the secretary in detail, a monthly report being required after the close of each month, and an annual report for each year ending with September 30.

4. *Publication of Results.* — The Board is required, under the provisions of the statutes, to report annually to the General Court the number of prosecutions made, and an itemized account of the money expended in carrying out the provisions of the law. (Chapter 75, section 7, Revised Laws.) This report has been made annually to the General Court in January since 1884.

A general summary of the work of the Board in this direction is also presented in the annual report of each year.

In addition to the foregoing the Board is required by a recent statute (Acts of 1902, chapter 272) to publish as often "as once each month in the official publication of the board, . . . a certificate of the examination or analysis made by authority of the board during the preceding month of any article of food manufactured or offered for sale in the Commonwealth, which is adulterated within the meaning of chapter seventy-five of the Revised Laws; and the board shall also cause to be published, with such

certificate of examination, a statement of the trade-mark, brand-mark, or name, with the name and place of business of the manufacturer, which appear upon the package or box containing such adulterated article, or with the name and place of business of the wholesale dealer of whom the goods were obtained."

The official publication referred to in the foregoing statute is the weekly bulletin of the Board, which has been published continuously during the past twenty years, and distributed principally to the health authorities of the cities and towns.

The work of the Board in carrying out the provisions of this recent statute has had a wholesome effect in suppressing certain adulterations which it had hitherto been found difficult to correct. Some of these were produced in the State, others outside the State. Many letters received from manufacturers of the latter class of articles give proof that the publication of the results of analysis has had the effect evidently intended by the framers of the statute. In many instances an intention was expressed by such manufacturers to comply with the Massachusetts laws upon this subject.

5. *Warning Notices.* — If the laws relative to the sale of adulterated articles were to be rigidly enforced in all instances much hardship must necessarily ensue, since there are many retailers who cannot, without considerable expense, be informed as to the quality of the goods which they offer for sale. Hence provision is made by the Board whereby retailers and dealers who are not manufacturers or producers may, if not previously complained of in court, be notified or warned of any violation of the statutes relative to adulteration, and of their liability to prosecution on a repetition of the sale. (See Manual of Health Laws, Regulation 10, p. 133.) By means of this warning notice, very much friction has been avoided, and the desired object secured, since the retailer usually transmits the notice or a copy of the same to the producer or wholesale dealer. In many cases evidence is thus secured for the conviction of the wholesaler or offending party, if within the State, or his exposure by publication, if outside the State.

6. *Prosecutions.* — In carrying out the provisions of the statutes relative to food and drug inspection it has always been the object of the Board to secure the conviction of the actual offender, the party who knowingly sells adulterated articles. This is usually a producer or wholesaler, but it is also true that the retailer occasionally purchases the adulterated articles with a full knowledge of their quality. Instances have quite recently occurred in which a retailer has received notice of the adulteration of certain articles which he offers for sale and has taken no notice of the warning. There is good reason in such cases for proceeding against the retailer.

So many amendments have been made to the statutes relative to food

and drug inspection in the past twenty years as to increase the circumstances and conditions under which the law may be violated in some directions and to limit and modify them in others. For example, the laws relating to the use of labels and the use of preservatives in food are now so explicit as to constitute new infractions of law where cases could not be brought in court under earlier statutes.

Great pains have been taken in every instance to prevent actual injustice in the matter of complaints against offenders.

7. *General Supervision of Work.* — The supervision of this work is, by the regulations of the Board, entrusted to the secretary.

In the present report, as well as in those of previous years, milk and milk products hold an important place, not only in consequence of the provision of the statutes, which sets apart a definite portion of the appropriation for that purpose, but also on account of the actual value of these products as a part of the food supply of the people, and their liability to serious adulteration.

In recent years legislation has been enacted which creates a practical classification of samples of milk, so far as the penalty for illegal sales is concerned. By the provisions of section 55 of chapter 56 of the Revised Laws the sale of milk "to which water has been added" is subject to a penalty of not *less* than fifty dollars. By a later statute (section 57, chapter 56, Revised Laws) the sale of "milk which is not of good standard quality" is subject to a penalty of not *more* than fifty dollars, that is to say, in the latter instance, milk of good standard quality in summer must contain 12 per cent. of total solids, including 3 per cent. of fat, and in winter 13 per cent. of solids, including $3\frac{7}{10}$ per cent. of fat (section 56 of the same chapter).

Now the difficulty of discriminating, in cases of samples having more than 11 per cent. of solids, between those "to which water has been added" and the entire general class of samples which are "not of good standard quality" must be recognized.

An examination of that part of the analyst's report entitled "The Detection of Watered Milk" shows that considerable progress has been made by the analyst during the past year in the methods of analysis employed for determining the constituents of milk as offered for sale, so that milk "to which water has been added" may be distinguished by means of chemical analysis from unadulterated milk of low standard.

Additional analyses have also been made of all new brands of condensed milk found in the market, and the publication of these, together with those which have already been published in previous reports, has had an excellent effect in stimulating competition. Many of the brands of poor quality have disappeared, so that the average quality of the condensed milk offered for sale is much higher than that of the earlier years. The enactment of a fat standard for condensed milk would probably result in further improvement.

Attention is also called to the statement of the analyst in regard to certain brands of cheese, the quality of which, on analysis, does not conform to the statements set forth in the labels attached to the wrappers.

With regard to the quality of vinegar sold in open market, the statutes provide definite standards. *First.* A standard of acetic acid of "not less than $4\frac{1}{2}$ per cent. by weight." *Second.* In the case of cider vinegar, "not less than 2 per cent. by weight of cider vinegar solids." *Third.* Cider vinegar must be "the legitimate product of pure apple juice." *Fourth.* Absence of artificial coloring matter.

Many analyses of this article of food, as obtained in open market, have been made during the year, and in addition a considerable amount of experimental work has been performed upon samples of vinegar of known purity, some of which were made in the laboratory and others were furnished by reputable manufacturers. The results of this work are presented in the report of the analyst.

Jams, jellies, preserves and flavoring extracts still constitute one of the most seriously adulterated groups of food now offered for sale. The devices employed by the substitution of glucose, starch, refuse fruit and seeds, water, cheap essential oils and aniline dyes in place of genuine products are very numerous. While some of these "cheap goods" conform fairly well to the provisions of statutes relating to labels, the actual consumer rarely receives any information as to their composition.

Three original papers of considerable importance have been added to the present report, entitled "The Determination of Glucose in Saccharine Products," "The Composition and Adulteration of Mustard," and "The Composition of Turmeric," these comprising the results of observations and experiments by the analysts of the Board upon these subjects.

Proprietary Medicines. — During the past twenty years the Board has published in its reports the results of such analyses as have been made by its chemists of different proprietary medicines which had been obtained in open market. These included lists of hair dyes and of opium cures in the report of 1885 (7th Supplement, Health, Lunacy and Charity); bitters and tonics in the nineteenth annual report, 1887; tonics and bitters, hair dyes and other poisonous cosmetics, blood purifiers or so-called sarsaparilla remedies, cocaine remedies for catarrh, etc., in the twenty-eighth annual report, 1896; and finally, a repetition of most of these lists in the thirty-fourth annual report, 1902. This repetition was made necessary by the constant and increasing demand for copies of the reports containing this information, whereby the limited editions provided by the statutes had become rapidly exhausted.

Advantage was therefore taken of the recent law of 1902 (chapter 230) by which the Board is "authorized to publish for general distribution such parts of its annual report, and such other matter as it may deem adapted to

promote the interests of the public health in this Commonwealth." Hence that portion of the report relating to this subject has, during the past two years, been published and distributed in pamphlet form. Requests for these reports have been received from all parts of the country, and in some instances periodicals having a very large circulation have published some of the lists of articles examined, either entire or in part.

There can be no doubt that the enormous consumption of proprietary medicines throughout the country is injurious to the health of the people, not only on account of the noxious ingredients which many of them contain and the consequent bad habits engendered by their frequent use, but also on account of the economic loss to the poor, who might find a far better use for the money thus expended in the purchase of good and wholesome food. Hypermedication is bad enough in the hands of the physician, but when self-administered by the masses who know nothing of therapeutics, its consequences are far worse.

The following lists contain the names of cities and towns to which warning notices of sales of adulterated food and drugs were sent in 1903, with the number of such sales in each instance: —

Cities and Towns to which Notices were sent on Account of Adulterated Milk in 1903.

Attleborough,	7	New Bedford,	4
Boston,	3	Newton,	9
Braintree,	1	North Adams,	6
Brockton,	7	Northampton,	1
Brookline,	1	Peabody,	1
Cambridge,	19	Pittsfield,	2
Carlisle,	3	Plymouth,	2
Chelsea,	27	Princeton,	3
Dedham,	9	Quincy,	12
Everett,	6	Revere,	8
Fall River,	8	Salem,	10
Fitchburg,	1	Salisbury,	3
Gardner,	2	Somerville,	26
Gloucester,	7	Springfield,	4
Haverhill,	9	Stoughton,	1
Holyoke,	4	Taunton,	2
Hyde Park,	8	Watertown,	4
Ipswich,	1	Webster,	2
Lawrence,	6	Weymouth,	1
Lowell,	14	Woburn,	7
Malden,	6	Worcester,	15
Marlborough,	1		
Medford,	3	Total,	282
Natick,	6		

Cities and Towns to which Notices were sent on Account of Adulterated Articles of Food Other than Milk.

Amesbury,	1	Natick,	1
Arlington,	1	New Bedford,	1
Ayer,	1	Newburyport,	4
Boston,	60	Newton,	1
Brockton,	1	North Adams,	8
Cambridge,	11	Northampton,	1
Chelsea,	2	Quincy,	1
Clinton,	2	Salem,	7
Danvers,	1	Somerville,	16
Fall River,	13	Springfield,	5
Greenfield,	2	Taunton,	2
Haverhill,	4	Waltham,	4
Lawrence,	3	Woburn,	2
Lowell,	12	Worcester,	7
Malden,	1		
Medford,	6	Total,	181

Cities and Towns to which Notices were sent on Account of Adulterated Drugs.

Ayer,	2	New Bedford,	1
Boston,	77	Newburyport,	2
Brockton,	1	North Adams,	9
Brookline,	1	Norwood,	3
Cambridge,	11	Pittsfield,	2
Chelsea,	8	Quincy,	1
Clinton,	2	Salem,	7
Concord,	5	Somerville,	8
Everett,	3	Springfield,	4
Fall River,	12	Waltham,	1
Fitchburg,	3	Webster,	2
Haverhill,	2	Westfield,	1
Holyoke,	5	Woburn,	1
Lexington,	1	Worcester,	4
Milford,	1		
Montague,	1	Total,	182
Needham,	1		

The following report treats of the operations of the Board under the provisions of the food and drug acts during the year ended Sept. 30, 1903. The report made to the Legislature in January, 1904, "of the number of prosecutions made under the act and an itemized account of the money expended in carrying out the provisions thereof," is also embodied in this annual report.

The following persons comprised the force employed by the Board during the year in this department: —

ALBERT E. LEACH,	*Analyst.*
CHARLES A. GOESSMANN,	*Analyst.*
HERMANN C. LYTHGOE,	*Assistant Analyst.*
JOHN F. MCCAFFREY,	*Inspector.*
JOHN H. TERRY,	*Inspector.*
HORACE F. DAVIS,	*Inspector.*

The number of samples of food and drugs examined during the year is shown in the accompanying table, together with a condensed summary of the work done since the beginning of this line of work in 1883: —

Number of samples of milk examined,	6,188
Number of samples above standard,	4,125
Number of samples below standard,	2,063
Percentage of adulteration or deficiency,	33.3
Number of samples of other kinds of food examined (not milk),	3,075
Number of samples above standard,	2,536
Number of samples below standard,	539
Percentage of adulteration,	17.5
Number of samples of drugs examined,	1,133
Number of samples of good quality,	662
Number of samples adulterated (as defined by the statutes),	471
Percentage of adulteration,	41.6
Total number of samples of food and drugs examined,	10,396
Total number found to be of good quality,	7,323
Total number found not conforming to the statutes,	3,063
Percentage of adulteration,	29.5

FOOD AND DRUG INSPECTION (1883–1903).

SUMMARY.	YEARS.		
	1902.	1903.	Total 1883-1903.
Number of samples of milk examined,	6,256	6,188	82,307
Number of samples above standard,	4,307	4,125	52,286
Number of samples below standard,	1,949	2,063	30,021
Percentage of adulteration,	31.1	33.3	36.5
Number of samples of other kinds of food examined (not milk),	3,090	3,075	52,010
Number of samples of good quality,	2,538	2,536	42,348
Number of samples adulterated, as defined by the statutes,	552	539	9,662
Percentage of adulteration,	17.8	17.5	18.6
Number of samples of drugs examined,	1,124	1,133	14,388
Number of samples of good quality,	636	662	8,782
Number of samples adulterated, as defined by the statutes,	488	471	5,606
Percentage of adulteration,	43.4	41.6	38.9
Total examinations of food and drugs,	10,470	10,396	148,705
Total examinations of good quality,	7,481	7,323	103,416
Total examinations not conforming to the statutes,	2,989	3,073	45,289
Percentage of adulteration,	28.1	29.5	30.5
Expense of collection, examination and prosecution,	$11,700 23	$11,711 43	$208,700 95
Expense of collection, examination and prosecution, per sample,	1 12	1 13	1 40

It appears from the foregoing table that 10,396 samples of food and drugs were collected and examined during the year ended Sept. 30, 1903, of which number 3,073, or 29.5 per cent., were found to be adulterated, or not up to the standard required by the statutes. This large ratio, however, does not represent the actual proportion of adulteration which actually exists in the general food supply. On the contrary, it far exceeds it, since the articles collected for examination are chiefly those which experience has shown to be specially liable to adulteration.

The whole number of samples of food and drugs examined since the beginning of work in 1883 was 148,705, of which 82,307, or more than one-half, as required by the statutes, were samples of milk.

The amount expended in the enforcement of the food and drug acts since the beginning of work has been $208,700.95, and the expense per sample $1.40 for the whole time. This expense was reduced from $2.26 per sample in 1883 to $1.13 in 1903.

The total amount of fines imposed for violation of the acts relating to food and drug inspection, up to Sept. 30, 1903, was $40,919.48.

PROSECUTIONS.

The following table presents the statistics relative to the prosecutions which have been conducted under the food and drug acts since the beginning of work in 1883 : —

Number of Complaints entered in Court.

Year.	Food and Other Articles (not including Milk).	Drugs.	Milk.	Total.	Convictions.	Fines imposed.
1883, ...	–	5	4	9	8	–*
1884, ...	2	1	45	48	44	–*
1885,†	50	1	68	119	103	–*
1886,‡	10	–	10	20	19	–*
1887, ...	30	–	34	64	60	–*
1888, ...	22	–	43	65	61	$2,042 00
1889, ...	74	–	66	140	124	3,889 00
1890, ...	78	–	24	102	96	3,919 00
1891, ...	96	5	49	150	135	2,668 00
1892, ...	52	12	72	136	123	3,661 70
1893, ...	26	3	67	96	92	2,476 00
1894, ...	14	–	76	90	77	2,625 00
1895, ...	13	11	68	92	86	2,895 30
1896, ...	7	–	68	75	74	2,812 20
1897, ...	13	1	51	65	64	2,756 60
1898, ...	10	–	54	64	62	2,060 98
1899, ...	19	2	26	47	45	1,432 66
1900, ...	45	5	44	94	89	1,890 70
1901, ...	30	–	65	95	90	1,874 70
1902, ...	25	3	48	76	74	2,617 98
1903, ...	34	1	44	79	70	1,297 66
	650	50	1,026	1,726	1,596	$40,919 48

* No record kept. † To May 1, 1886. ‡ Four months only.

Ratio of convictions to complaints, 92.5 per cent.

NOTE. — All complaints entered before May 1, 1886, were under the direction of the Board of Health, Lunacy and Charity, and all after that date were under the direction of the State Board of Health.

The number of prosecutions made against offenders during the year was 79, and the number of convictions 70.

The following report was transmitted to the Legislature Jan. 11, 1904, in compliance with the terms of the statute, section 7, chapter 75, Revised Laws: —

OFFICE OF THE STATE BOARD OF HEALTH,
STATE HOUSE, BOSTON, Jan. 11, 1904.

To the Honorable Senate and House of Representatives of the Commonwealth of Massachusetts in General Court assembled.

Under the provisions of the Revised Laws of Massachusetts, chapter 75, section 7, the State Board of Health is required to report annually "to the General Court the number of prosecutions made under the provisions

of sections sixteen to twenty-seven, inclusive, and an itemized account of the money expended in carrying out the provisions thereof." *

The following summary is, therefore, presented of the prosecutions and expenditures made during the year ended Sept. 30, 1903.

The names of the cities and towns in which the articles were sold, and in respect to which complaints were entered in court, the character of the articles adulterated or fraudulently sold, the dates of the trials, and their results, are presented in the following table: —

MILK AND MILK PRODUCTS.

For Fraudulent Sales of Milk.

PLACE.	DATE.	RESULT.
Chelsea,	Oct. 17, 1902,	Convicted.
Chelsea,	Aug. 7, 1903,	Convicted.
North Adams,	Dec. 4, 1902,	Convicted.
Haverhill,	Jan. 23, 1903,	Convicted.
Fall River,	April 24, 1903,	Convicted.
Fall River,	April 24, 1903,	Convicted.
Fall River,	May 1, 1903,	Convicted.
Fall River,	May 1, 1903,	Convicted.
Fall River,	May 1, 1903,	Convicted.
Fall River,	May 1, 1903,	Convicted.
Fall River,	May 1, 1903,	Convicted.
Fall River,	May 1, 1903,	Discharged.
Fall River,	Sept. 22, 1903,	Convicted.
Fall River,	Sept. 22, 1903,	Convicted.
Quincy,	May 14, 1903,	Convicted.
Quincy,	May 14, 1903,	Convicted.
New Bedford,	June 30, 1903,	Convicted.
Lowell,	Aug. 19, 1903,	Convicted.
Lowell,	Sept. 17, 1903,	Convicted.
Worcester,	Sept. 16, 1903,	Convicted.
Gloucester,	Sept. 17, 1903,	Convicted.
Gloucester,	Sept. 17, 1903,	Convicted.
Peabody,	Oct. 18, 1902,	Convicted.
Peabody,	Oct. 18, 1902,	Convicted.
Peabody,	Oct. 18, 1902,	Convicted.
Peabody,	Oct. 25, 1902,	Convicted.
Holbrook,	Nov. 20, 1902,	Convicted.
Holliston,	Nov. 13, 1902,	Convicted.
Dunstable,	Nov. 22, 1902,	Died before trial.
Dunstable,	Nov. 25, 1902,	Convicted.
Bolton,	Dec. 24, 1902,	Convicted.

* These sections (16 to 27, chapter 75, Revised Laws) have now been published, together with all the other statutes relating to food and drug inspection, in a pamphlet authorized by chapter 230 of the Acts of 1902. Copies of this pamphlet can be had at the office of the State Board of Health, Room 141, State House.

For Fraudulent Sales of Milk — Concluded.

PLACE.	DATE.	RESULT.
Spencer,*	Feb. 3, 1902,	Convicted.
Dedham,	March 19, 1902,	Convicted.
Swansea,	May 15, 1902,	Convicted.
Swansea,	May 15, 1902,	Convicted.
Maynard,	May 2, 1903,	Convicted.
Maynard,	May 2, 1903,	Convicted.
Dover,	July 30, 1903,	Convicted.
Plymouth,	June 24, 1903,	*Nol pros.*
Plymouth,	June 8, 1903,	Discharged.
Gardner,	Aug. 24, 1903,	Convicted.
Gardner,	Sept. 5, 1903,	Convicted.
Chelmsford,	Sept. 19, 1903,	Convicted.
Chelmsford,	Sept. 19, 1903,	Convicted.

Butter.

Watertown,	July 18, 1902,†	Convicted.
North Adams,	Oct. 17, 1902,	Convicted.
North Adams,	Nov. 22, 1902,	Discharged.
North Adams,	Dec. 4, 1902,	Convicted.

Cheese.

Charlemont,	April 10, 1903,	Discharged.
Boston,	Nov. 12, 1903,	Convicted.
Boston,	Aug. 4, 1903,	Convicted.

OTHER ARTICLES OF FOOD.

Lard.

Medford,	Dec. 30, 1902,	Convicted.
Malden,	Dec. 30, 1902,	Convicted.
Malden,	Dec. 30, 1902,	Convicted.
Malden,	Dec. 30, 1902,	Convicted.
Lawrence,	Jan. 3, 1903,	Convicted.
Lawrence,	Jan. 3, 1903,	Convicted.
Lawrence,	Jan. 6, 1903,	Convicted.
Lawrence,	Jan. 6, 1903,	Convicted.
Lawrence,	Jan. 6, 1903,	Convicted.
Lawrence,	Jan. 6, 1903,	Convicted.
Lawrence,	Jan. 6, 1903,	Convicted.
Chelsea,	Jan. 19, 1903,	Convicted.
Chelsea,	Jan. 26, 1903,	Convicted.
Chelsea,	Jan. 26, 1903,	Convicted.

* This was the worst sample of milk ever collected by an inspector of the Board. It was sold by one Casey of Charlton, and consisted of a mixture of about one part of milk and two parts of water, the total solids being only 4.10.

† Omitted in the report of previous year.

Molasses.

Place.	Date.	Result.
North Adams, . . .	Dec. 4, 1902, . . .	Convicted.
North Adams, . . .	Dec. 4, 1902, . . .	Convicted.

Honey.

Boston, ...	Sept. 2, 1903, . . .	Discharged.

Coffee.

North Adams, . . .	Dec. 4, 1902, . . .	Convicted.
North Adams, . . .	Dec. 4, 1902, . . .	Convicted.

Spices.

North Adams, . . .	Dec. 4, 1902, . . .	Convicted.
North Adams, . . .	Dec. 4, 1902, . . .	Convicted.

Mustard.

North Adams, . . .	Dec. 4, 1902, . . .	Convicted.
Chelsea, ...	Feb. 5, 1903, . . .	Discharged.

Cassia.

North Adams, . . .	Dec. 4, 1902, . . .	Convicted.

Ginger.

North Adams, . . .	Dec. 4, 1902, . . .	Convicted.

Canned Peas.

North Adams, . . .	Dec. 4, 1902, . . .	Convicted.

DRUGS.

Tincture of Iodine.

Nantucket, . . .	Sept. 28, 1903, . . .	Convicted.

OTHER ARTICLES.

Cloth containing Arsenic.

Boston, ...	Oct. 17, 1902, . . .	*Nol pros.*

SUMMARY.

The number of complaints entered by the State Board of Health during the year ended Sept. 30, 1903, in the courts of the Commonwealth, against parties for violation of the statutes relating to the inspection of food, drugs and other articles in common use, was 79.

In 70, or 88.6 per cent., the parties were convicted; 8 were discharged; and in one instance the person against whom complaint was made died before the date which had been assigned for the trial.

Of the whole amount, 44 were for violation of the statutes relating to milk and milk products, and of this number 40 resulted in conviction. The greater number of these were for violation of the statutes providing that milk offered for sale shall be of good standard quality. In 6 of these cases coloring matter, either aniline dyes or annatto, had been used for coloring the milk; and in 3 cases either formaldehyde or boric acid had been introduced as a preservative.

The other articles of food with reference to which complaints were made were as follows: —

Butter and oleomargarine, 4 cases, 2 of which were for fraudulent sales of renovated butter and 2 of oleomargarine.

Cheese, 3 cases, all for fraudulent sales of so-called cream cheese, which were not cream cheese.

Lard, 14 cases, all for sales of lard adulterated with foreign fats.

Molasses, 2 cases, adulteration with glucose.

Honey, 1 case, adulteration with sugar.

Coffee, 2 cases.

Spices: pepper, 2 cases; mustard, 2 cases; cassia, 1 case; ginger, 1 case.

Canned peas, 1 case; sale of canned, soaked peas, not properly marked.

The complaint entered for a sale of adulterated drugs was for a sale of tincture of iodine below the required standard.

The total number of samples of food and drugs examined during the year was as follows: —

Milk,	6,188
Other articles of food,	3,075
Drugs,	1,133
Total,	10,396
Liquors,	210
Wall papers examined for arsenic,	17
Total expenses of collection, examination and prosecution,	$11,711 43
Average expense for samples collected,	1 13

The whole number of samples of food and drugs examined in this department since the beginning of work in 1883 was 148,705, and the number of complaints entered in court was 1,726.

The average cost per sample, for collection, analysis and other work, has been reduced from $2.26 per sample in 1883 to $1.13 in 1903.

The following list presents the total solids in each of the samples of milk upon which complaints were founded, so far as records of the same were kept: —

4.10	9.76	10.20	10.72	11.00	11.40
8.40	9.84	10.25	10.72	11.11	11.40
9.32	10.00	10.30	10.73	11.30	11.40
9.60	10.07	10.34	10.80	11.31	12.00
9.70	10.19	10.48	10.80	11.35	12.40
9.70	10.20	10.60	10.99	11.39	12.88

The foregoing figures represent a large number of samples examined, since very many of the complaints were founded upon collections of milk made at dairy farms, where the collector often takes at each instance as many as 15 to 20 samples at a single dairy for analysis; but each complaint is made upon the analysis of a single sample selected from the lot, and these selected samples only are represented in the foregoing list.

The addition of the work of liquor analysis under the provisions of recent statute diminishes the apparent work in the line of food inspection, since it involves the employment of officials at court who might be otherwise engaged.

Fines.

The amount of fines paid into treasuries of counties, cities and towns, under the provisions of the general and special acts relating to inspection of food, drugs and other articles in common use during the year ended Sept. 30, 1903, was as follows: —

Fines paid for violation of the acts relating to milk and milk products,	$1,022 66
Fines paid under other laws relating to food and other articles liable to inspection,	275 00
Total,	$1,297 66

The very considerable reduction in the amount of the fines imposed by the courts is due chiefly to the recent change in the statute providing a penalty for the sale of milk "not of good standard quality." Under the former statute, chapter 318, section 2, Acts of 1886, the penalty for a first offence under the law was fixed at "not less than fifty dollars;" but by the Acts of 1900, chapter 300, section 2 (Revised Laws, chapter 56, section 57), this phrase was changed to "not *more* than fifty dollars."

A reduction was also made in the fine for sale of renovated butter from a minimum of $100 to a minimum of $25 for a first offence.

The whole amount of fines imposed for violation of the acts mentioned in this summary relating to food and drug inspection, up to Sept. 30, 1903, was $40,919.48.

EXPENDITURES

Under the Provisions of the Food and Drug Acts during the Year ending Sept. 30, 1903.

Salaries of analysts,	$4,629 99
Salaries of inspectors,	4,503 33
Travelling expenses and purchase of samples,	1,919 02
Apparatus and chemicals,	308 05
Printing,	61 59
Special investigations,	25 00
Services (cleaning laboratory),	104 00
Express and telegrams,	7 71
Sundry laboratory supplies,	100 84
Books,	39 90
Extra services (stenographer),	12 00
Total,	$11,711 43

The appropriation was increased during the year by the provisions of chapter 467, Acts of 1903, from $11,500 to $12,500.

SAMUEL W. ABBOTT, *Secretary.*

REPORT OF THE ANALYST.

By Albert E. Leach.

REPORT OF THE ANALYST.

By ALBERT E. LEACH.

Dr. S. W. ABBOTT, *Secretary State Board of Health.*

DEAR SIR: — I herewith submit my report on the analysis of food and drugs for the year ending Sept. 30, 1903.

This year is the twenty-first in the work of continuous food and drug inspection in Massachusetts, and the chart on the following page is introduced to show the variation in adulteration of various foods during this period.

The abscissæ represent the calendar years, and the ordinates the percentage of adulteration. There are many reasons to account for the somewhat varied character of these curves, all of which show, however, a marked general improvement during the period of inspection. It should be understood in the first place that the actual adulteration of all these foods is much less than would be inferred from the character of the curves, due to the fact that to a great extent samples are collected from suspicious sources, or with reference to their suspicious character, so that the ratio of adulteration of the foods analysed in the laboratory is much higher than that of the same foods sold on the market.

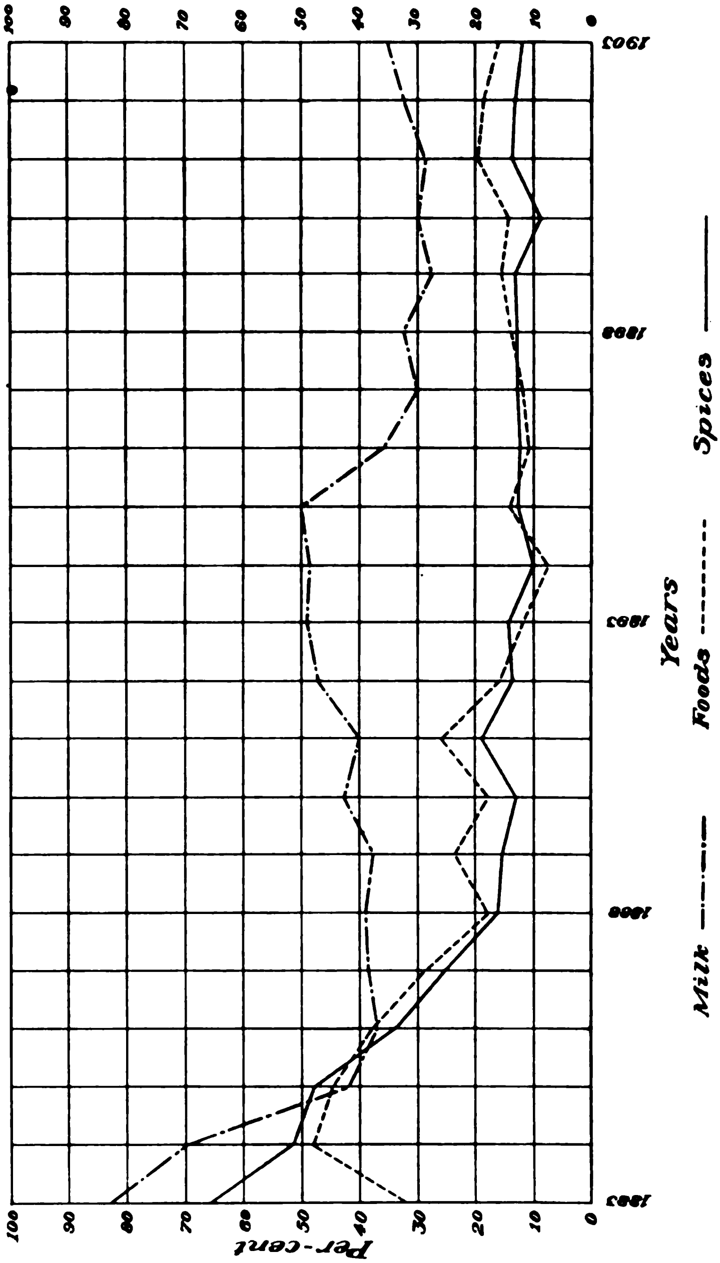
Variations in the broken line representing milk are due: (1) to legislative changes in the milk standard, additional months being transferred from time to time from the 13 per cent. to the 12 per cent. standard; (2) to the fact that in some years large numbers of samples of milk of known purity have been collected, while in other years more attention has been given to the collection of milk from suspected producers, the latter commonly resulting from complaints made to the Board.

Variations in the dotted curve, representing foods exclusive of milk, are largely due to the fact that the character of the foods inspected varies from year to year to some extent, new varieties being from time to time examined.

The full line, representing spices, has been introduced for the reason that this is a class of foods most liable of all to adulteration, and has from the start received the unremitting attention of the Board. It is thus, of all classes, the one best adapted to show the beneficial results of careful inspection.

Diagram Illustrating the Variation in Adulteration of Food in Massachusetts

during the twenty-one years 1883-1903



United States Standards of Purity for Food Products.

Under an act of Congress, approved June 3, 1903, standards of purity for certain articles of food, including meat and meat products, milk and its products, sugar and related substances, spices, cocoa and cocoa products, were later established as official standards for the United States by the Secretary of Agriculture. Schedules are yet to be adopted and are in process of preparation in the following classes: grains, fruits and vegetables, honey, fruit extracts, salad oils, salt, tea, coffee, fruit juices, alcoholic and carbonated beverages, vinegar, preservatives and coloring matters.

It is obviously an advantage to have official standards to rely upon in cases where our State laws do not provide such standards.

Publication of Results of Analysis.

One of the most effective means of suppressing adulteration consists in publishing the brands of adulterated foods, together with the names and addresses of their manufacturers. It was formerly the custom in some cases to report as well the names of pure brands, but experience has shown that, while such a list is no doubt useful for the information of the public, there are many disadvantages, chief among which is the objectionable use of such a list by the makers of these brands for advertising purposes in a manner detrimental to honest competition. Therefore, adulterated brands only are now made public.

During the present year, under a recent statute, lists of adulterated brands of food, and in some cases of drugs, were published in the Board's monthly bulletin, together with the results of the analyses.

Milk.

The ratio of adulteration of milk examined, namely, 32.4 per cent., is the highest for some years. This is partly due to the fact that more suspicious samples than usual have been collected. The usual statistics of the milk collected from cities, towns and suspected producers are found in the following tables: —

Milk from Cities.

Cities.	Number above Standard.	Number below Standard.	Total Samples collected.	Per Cent. below Standard.	Total Solids in Lowest Sample.	Number of Skimmed Samples.	Number of Samples colored with — Annatto.	Aniline Orange.	Caramel.	Number of Samples preserved with — Formaldehyde.	Boric Acid.	Soda.
Boston, ...	193	44	237	18.6	11.63	-	-	-	-	-	-	-
Brockton, . . .	110	36	146	24.6	10.00	-	-	-	-	2	-	-
Cambridge, . . .	223	149	372	24.9	9.93	-	-	-	-	-	-	-
Chelsea, ...	167	149	316	21.1	10.24	-	-	-	-	-	-	-
Everett, ...	89	76	165	41.6	10.96	-	-	-	-	-	-	-
Fitchburg, . . .	28	7	35	20.0	9.12	2	-	-	-	-	-	-
Fall River, . . .	156	47	203	23.1	9.76	-	2	-	-	5	-	-
Gloucester, . . .	59	29	88	33.0	9.62	-	2	-	-	-	-	-
Haverhill, . . .	105	71	176	40.3	7.70	1	-	-	-	-	-	-
Lawrence, . . .	97	73	170	42.9	8.40	7	-	-	-	-	-	1
Lowell, ...	59	56	115	47.6	8.40	3	-	1	-	-	-	-
Malden, ...	93	49	142	34.5	9.60	-	-	-	-	-	-	-
Marlborough, . .	72	19	91	20.9	9.12	5	-	-	-	-	-	-
Medford, . . .	44	46	90	51.1	10.29	-	-	-	-	-	-	-
New Bedford, . .	73	31	104	29.8	9.55	-	-	-	-	-	-	-
Newburyport, . .	109	29	138	20.3	11.66	-	-	-	-	-	-	-
Newton, . . .	83	68	151	38.4	10.19	-	2	-	-	2	-	-
North Adams, . .	52	37	89	41.6	9.58	1	-	-	-	2	-	-
Quincy, ...	89	28	117	23.9	9.60	1	-	-	-	-	-	-
Salem, ...	102	42	144	29.2	9.30	-	-	3	-	9	-	-
Somerville, . . .	269	183	452	24.9	9.67	-	-	-	-	-	3	-
Taunton, . . .	118	14	132	10.6	10.16	-	-	-	1	-	-	-
Waltham, . . .	81	22	53	41.6	10.26	-	-	-	-	-	-	-
Woburn, . . .	3	13	16	81.4	9.20	-	-	-	-	-	-	-
Worcester, . . .	177	89	266	33.5	10.07	-	1	-	-	-	-	-
Summary, . .	2,601	1,407	4,008	35.1	8.40	20	7	4	1	20	3	1

Milk from Towns.

Towns.	Number above Standard.	Number below Standard.	Total Samples collected.	Per Cent. below Standard.	Total Solids in Lowest Sample.	Number of Skimmed Samples.	Number of Samples colored with — Annatto.	Aniline Orange.	Caramel.	Number of Samples preserved with — Formaldehyde.	Boric Acid.	Soda.
Abington,	3	1	4	25.0	11.86	-	-	-	-	-	-	-
Athol,	11	-	11	0.0	12.35	-	-	-	-	-	-	-
Attleborough,	72	42	114	36.8	9.93	4	-	-	-	-	-	-
Beverly,	31	7	38	18.4	7.57	2	-	-	-	-	-	-
Braintree,	16	1	17	5.9	12.12	-	-	-	-	1	-	-
Brookline,	75	35	110	31.8	10.35	-	-	-	-	-	-	-
Clinton,	28	6	34	17.6	9.67	5	-	-	-	-	-	-
Dedham,	57	24	81	29.7	11.90	-	-	-	-	-	-	-
Gardner,	17	2	19	10.5	11.50	-	-	-	-	1	1	-
Hyde Park,	90	37	127	29.1	10.26	-	-	-	-	-	-	-
Ipswich,	10	7	17	41.2	11.48	-	-	-	-	-	-	-
Lenox,	20	-	20	0.0	12.12	-	-	-	-	-	-	-
Manchester,	10	-	10	0.0	12.00	-	-	-	-	-	-	-
Milford,	59	2	61	3.3	12.00	-	-	-	-	-	-	-
Nantucket,	24	2	26	7.7	9.57	-	-	-	-	-	-	-
Natick,	58	14	72	19.5	9.29	1	-	-	-	-	-	-
Needham,	10	-	10	0.0	13.00	-	-	-	-	-	-	-
Peabody,	2	3	5	60.0	10.63	-	-	-	-	-	-	-
Pepperell,	-	8	8	100.0	10.99	-	-	-	-	-	-	-
Plymouth,	31	4	35	11.4	10.80	-	-	-	-	5	-	-
Provincetown,	25	8	33	24.2	11.39	-	-	-	-	-	7	-
Revere,	97	56	153	36.6	10.67	-	-	-	-	-	-	-
Salisbury,	13	3	16	18.7	10.00	-	-	-	-	-	-	-
Saugus,	7	1	8	12.5	11.70	-	-	-	-	-	-	-
Stoughton,	59	32	91	35.2	10.50	-	-	-	-	-	-	-
Wareham,	12	1	13	7.7	11.26	-	-	-	-	-	-	-
Watertown,	61	54	115	46.9	11.69	-	-	-	-	1	-	-
Webster,	34	6	40	15.0	11.49	-	-	-	-	-	-	-
Westborough,	26	5	31	16.1	11.60	-	-	-	-	-	-	-
Westwood,	2	-	2	0.0	12.52	-	-	-	-	-	-	-
Weymouth,	9	1	10	10.0	11.88	-	-	-	-	-	-	-
Whitman,	19	3	22	13.6	11.33	-	-	-	-	-	-	-
Winchester,	5	3	8	37.5	12.64	-	-	-	-	-	-	-
Winthrop,	49	31	80	38.8	11.45	-	-	-	-	-	-	-
Summary,	1,052	389	1,441	27.0	7.57	12	-	-	-	8	8	-

Milk from Suspected Producers.

Locality.	Number above Standard.	Number below Standard.	Total Samples collected.	Per Cent. below Standard.	Total Solids in Lowest Sample.	Number of Samples colored with Annatto.
Bedford,	2	5	7	71.4	11.82	-
Bolton,	-	2	2	100.0	9.60	-
Braintree,	14	6	20	30.0	11.30	-
Brimfield,	6	-	6	0.0	12.14	-
Canton,	8	4	12	33.3	11.20	-
Carlisle,	-	6	6	100.0	10.99	-
Concord,	-	4	4	100.0	11.80	-
Dedham,	18	27	35	77.2	10.20	-
Dover,	4	6	10	60.0	10.25	-
Easton,	12	-	12	0.0	12.88	-
Holbrook,	-	15	15	0.0	9.60	-
Maynard,	1	5	6	83.3	11.31	-
Needham,	2	11	13	84.7	10.14	-
Norfolk,	16	3	19	15.8	10.84	-
Norwood,	9	2	11	18.2	11.71	-
Palmer,	5	3	8	37.5	10.72	-
Princeton,	3	3	6	50.0	10.25	-
Somerset,	15	2	17	38.5	11.14	-
Spencer,	4	15	19	-	4.10	-
Stoughton,	2	3	5	60.0	11.00	-
Swansea,	9	11	20	55.0	10.74	10
Walpole,	13	0	13	0.0	12.33	-
Waltham,	20	17	37	63.1	12.05	-
Wayland,	5	14	19	73.7	10.72	-
Summary,	158	164	322	50.9	4.10	10

Summary of Milk Statistics.

	Number above Standard.	Number below Standard.	Total Samples collected.	Per Cent. below Standard.	Total Solids in Lowest Sample.	Number of Skimmed Samples.	Number of Samples colored with — Annatto.	Aniline Orange.	Caramel.	Number of Samples preserved with — Formaldehyde.	Boric Acid.	Soda.
Cities,	2,601	1,407	4,008	35.1	8.40	20	7	4	1	20	3	1
Towns,	1,052	389	1,441	27.0	7.57	12	-	-	-	8	8	-
Suspected producers,	158	164	322	50.9	4.10	-	10	-	-	-	-	-
Miscellaneous,	3	19	22	86.4	11.84	-	-	-	-	-	-	-
Summary,	3,814	1,979	5,793	34.2	4.10	32	17	4	1	28	11	1

Quality of Milk by Months.

	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Totals.
Number having more than 15 per cent. of total solids,	17	22	33	24	4	15	14	7	14	18	13	18	199
Number having between 14 and 15 per cent. of total solids,	42	50	65	52	50	42	20	28	24	34	27	23	457
Number having between 13 and 14 per cent. of total solids,	123	152	195	150	166	114	129	130	128	139	128	98	1,652
Number having between 12 and 13 per cent. of total solids,	246	181	126	205	241	271	248	286	231	248	247	234	2,759
Number having between 11 and 12 per cent. of total solids,	38	15	21	22	20	44	63	45	50	73	62	53	506
Number having between 10 and 11 per cent. of total solids,	20	9	5	9	10	6	18	18	12	11	11	22	151
Number having between 9 and 10 per cent. of total solids,	4	5	4	2	5	4	5	9	3	5	3	4	53
Number having between 8 and 9 per cent. of total solids,	-	1	1	1	-	2	-	-	-	-	2	-	7
Number having less than 8 per cent. of total solids,	-	1	-	3	-	-	-	2	-	-	-	-	6
Number of samples of skimmed milk above the standard,	1	1	1	3	1	-	-	5	-	6	-	-	18
Number of samples of skimmed milk below the standard,	-	2	-	2	2	5	1	1	1	-	-	2	16

Samples of artificially colored milk were collected from Fitchburg, Lowell, Gloucester, Newton, Salem, and Swansea. Samples of milk with added preservatives were collected from Brockton, Fall River, Lawrence, Newton, North Adams, Salem, Somerville, Braintree, Gardner, Plymouth, Provincetown, and Watertown.

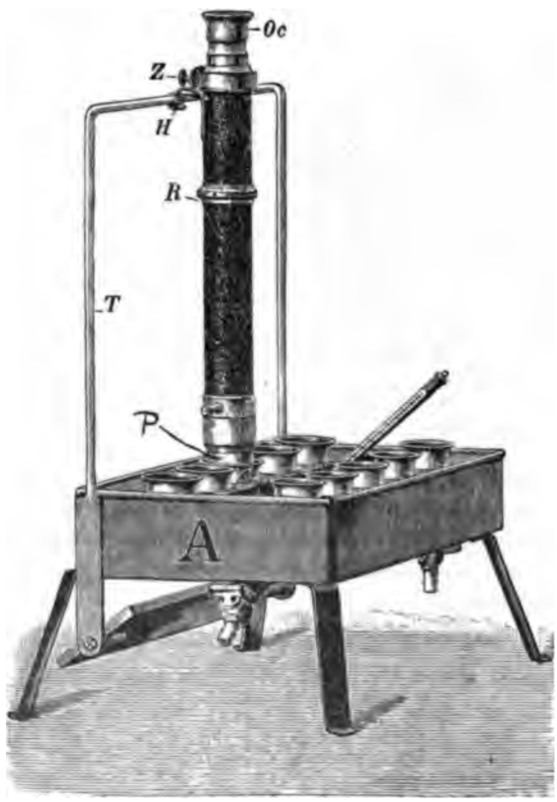
The Detection of Watered Milk.

One of the most difficult problems with which the analyst is confronted is that of distinguishing between what might be termed honest low-standard milk, or milk below the standard coming from the cow as such, and milk that is fraudulently watered. Judgment on this point has heretofore been based largely on the relative proportion of fat to solids not fat, taken in connection with an abnormally low total solids. Additional information on this question is furnished by the density of the milk serum, when the milk has been curdled under fixed conditions, though this in itself is by no means conclusive.

The addition of water to milk perceptibly affects the degree of refraction of the serum, to such an extent that this latter constant promises to be a most helpful one in determining whether or not the milk has been watered. For this purpose the immersion refractometer of Zeiss is most useful, although the Abbé refractometer may be employed. Much of the credit for working out this process is due to H. C. Lythgoe.

The Zeiss Immersion Refractometer. — The construction of this instrument is such that, as its name implies, it may be directly immersed in a

solution, the degree of refraction of which, within limits, may be determined upon an arbitrary scale. The accompanying figure shows this instrument, for a detailed description of which the reader is referred to the Journal of the American Chemical Society, volume 26 (October, 1904).*



If, however, the Abbé instrument is used, tables are available for the conversion of indices of refraction into scales readings of the immersion refractometer.

Method of Procedure. — The method of curdling milk employed in this laboratory is that of Woodman,† as follows: —

To 100 cubic centimeters of milk, at a temperature of about 20° C., are added 2 cubic centimeters of 25 per cent. acetic acid (specific gravity 1.0350) in a beaker, and the beaker, covered with a watch glass, is heated in a water bath for twenty minutes at a temperature of 70° C. After this the beaker is placed in ice water for ten minutes, and the solution filtered.

* The Detection of Watered Milk, by Albert E. Leach and Hermann C. Lythgoe.
† Journal American Chemical Society, 21 (1899), p. 503.

The refractometer is placed directly in the clear filtrate. The following table, No. 1, shows analyses of milk selected from a wide range of samples regularly collected and examined in the routine of inspection: —

TABLE No. 1.— *Constants of Milk and Milk Serum. Laboratory Samples.*

Determinations on Milk.						Determinations on Milk Serum.	
Total Solids (Per Cent.).	Water (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Ash (Per Cent.).	Specific Gravity at 15° C.	Specific Gravity at 15° C.	Immersion Refractometer Reading at 20° C.
16.45	83.55	8.20	8.25	-	1.0255	1.0274	40.95
15.90	84.10	7.00	8.90	.69	1.0277	1.0285	42.00
14.37	85.63	5.50	8.88	.58	1.0282	1.0280	42.40
14.17	85.83	4.85	9.32	.62	1.0313	1.0281	44.20
14.04	85.96	4.95	9.09	.60	1.0303	1.0274	42.70
13.80	86.20	5.00	8.80	.63	1.0302	1.0289	42.75
13.59	86.41	4.30	9.29	.64	1.0321	1.0285	44.50
13.39	86.61	4.40	8.99	.50	1.0324	1.0285	43.70
13.28	86.72	4.40	8.88	.60	1.0299	1.0289	42.65
13.12	86.88	4.00	9.12	.59	1.0317	1.0280	43.75
13.00	87.00	4.30	8.70	.56	1.0310	1.0266	42.60
12.90	87.10	3.85	9.05	.61	1.0318	1.0289	43.40
12.80	87.20	4.30	8.50	.46	1.0304	1.0277	42.70
12.70	87.30	3.80	8.90	.53	1.0314	1.0280	43.10
12.63	87.37	3.50	9.13	.65	1.0323	1.0277	43.65
12.62	87.38	4.10	8.52	.52	1.0298	1.0272	42.40
12.57	87.43	3.70	8.87	.68	1.0317	1.0278	43.45
12.47	87.53	3.60	8.87	.65	1.0303	1.0282	43.15
12.36	87.64	3.20	9.16	.55	1.0327	1.0282	43.25
12.30	87.70	3.20	9.10	.62	1.0327	1.0283	44.00
12.16	87.84	4.35	7.81	.49	1.0275	1.0265	41.10
12.00	88.00	3.40	8.60	.62	1.0275	1.0282	41.75
11.86	88.14	3.60	8.26	.49	1.0306	1.0266	42.40
11.67	88.33	3.95	7.77	.48	1.0265	1.0240	39.30
11.60	88.40	2.75	8.85	.65	1.0320	1.0282	43.55
11.50	88.50	3.45	8.05	.51	1.0290	1.0269	41.40
11.40	88.60	3.10	8.30	.60	1.0297	1.0278	42.00
11.25	88.75	2.80	8.45	.58	1.0280	1.0274	40.90
11.07	88.93	3.00	8.07	.62	1.0290	1.0270	40.75
10.69	89.31	2.95	7.74	-	1.0288	1.0262	39.85
10.25	89.75	3.20	6.95	.55	1.0230	1.0223	36.40
8.34	91.66	2.20	6.14	.38	1.0224	1.0207	34.70

The following table, No. 2, shows analyses of a whole milk submitted by the writer to varying degrees of watering up to 50 per cent. of added water: —

TABLE NO. 2.— *Constants of Milk and Milk Serum. A Whole Milk Systematically Watered.*

Determinations on Milk.							Determinations on Milk Serum.	
Added Water (Per Cent.).	Total Solids (Per Cent.).	Water (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Ash (Per Cent.).	Specific Gravity at 15° C.	Specific Gravity at 15° C.	Immersion Refractometer Reading at 20° C.
0, . .	12.65	87.35	4.00	8.65	.65	1.0315	1.0287	42.40
10, . .	11.33	88.67	3.50	7.83	.60	1.0278	1.0260	39.75
20, . .	10.10	89.90	3.10	7.00	.53	1.0252	1.0230	36.90
30, . .	8.95	91.05	2.80	6.15	.48	1.0211	1.0200	34.10
40, . .	7.67	92.33	2.40	5.27	.40	1.0192	1.0167	31.10
50, . .	6.43	93.57	2.00	4.43	.38	1.0154	1.0140	28.45

Table No. 3 shows a centrifugally skimmed milk, systematically watered up to 50 per cent. of added water as in Table No. 2. It will be observed that both the specific gravity and immersion refractometer readings of the serum in Table No. 2 agree very closely with those of the skimmed milk in Table No. 3, having a corresponding amount of water.

TABLE NO. 3.— *Constants of Milk and Milk Serum. A Skimmed Milk Systematically Watered.*

Determinations on Milk.							Determinations on Milk Serum.	
Added Water (Per Cent.).	Total Solids (Per Cent.).	Water (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Ash (Per Cent.).	Specific Gravity at 15° C.	Specific Gravity at 15° C.	Immersion Refractometer Reading at 15° C.
0, . .	9.05	90.95	.03	9.02	.64	1.0350	1.0296	42.85
10, . .	8.14	91.86	.03	8.11	.60	1.0317	1.0260	39.60
20, . .	7.27	92.73	.02	7.25	.56	1.0278	1.0230	36.85
30, . .	6.41	93.59	.02	6.39	.48	1.0247	1.0200	34.00
40, . .	5.50	94.50	.01	5.49	.44	1.0209	1.0170	31.20
50, . .	4.61	95.39	.01	4.60	.39	1.0172	1.0140	28.50

A comparison of the immersion refractometer readings of the sera of milk of varied quality shows at once that the refraction of the serum is a general index to watering. A reading below 40 degrees, with the above conditions carefully observed, would be suspicious of added water, though we are at present inclined to adopt 39 as a safer limit below which milk

could be declared fraudulently watered. The following table, No. 4, shows results of analyses of milk of known purity taken from a herd of Holstein cows, milked in the presence of one of the inspectors. The daily rations of each cow consisted of six quarts of shorts, two quarts of cotton-seed meal and two quarts of corn meal with hay.

TABLE No. 4.—*Milk of Known Purity from Holstein Cows.*

Age of Cow (Years).	Time since Calving (Months).	Determinations on Milk.								Determinations on Milk Serum.		
		Specific Gravity at 15° C.	Water (Per Cent.).	Total Solids (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Ash (Per Cent.).	Milk Sugar (Per Cent.).	Proteids (Per Cent.).	Specific Gravity at 15° C.	Immersion Refractometer Reading at 20° C.	n_D at 20° C.
2, . . .	2	1.0317	87.26	12.74	3.70	9.04	.60	4.80	3.64	1.0297	44.4	1.344408
3, . . .	4	1.0303	87.37	12.63	4.00	8.36	.66	4.55	3.42	1.0290	42.8	1.343804
6, . . .	12	1.0296	87.68	12.32	3.90	8.42	.63	4.20	3.59	1.0286	42.3	1.343614
3, . . .	4	1.0307	87.77	12.23	3.80	8.43	.50	4.20	3.73	1.0289	42.9	1.343842
6, . . .	12	1.0296	87.84	12.16	3.45	8.71	.60	4.10	4.01	1.0297	43.5	1.344070
2, . . .	2	1.0312	87.88	12.12	3.40	8.72	.74	4.75	3.23	1.0329	44.5	1.344445
7, . . .	12	1.0301	88.11	11.89	3.40	8.49	.70	4.35	3.44	-	43.7	1.344146
12, . . .	5	1.0301	88.24	11.76	3.40	8.36	.54	4.80	3.02	-	42.9	1.343842
2, . . .	2	1.0289	88.33	11.67	3.55	8.12	.60	4.50	3.02	1.0297	43.2	1.343956
5, . . .	4	1.0300	88.37	11.63	3.30	8.33	.58	4.75	3.00	1.0289	43.6	1.344108
4, . . .	6	1.0297	88.41	11.59	3.20	8.39	.62	4.40	3.37	1.0290	42.9	1.343842
5, . . .	½	1.0304	88.43	11.57	3.30	8.27	.62	4.70	2.95	1.0318	43.0	1.343880
3, . . .	4	1.0311	88.51	11.49	3.25	8.24	.62	4.35	3.27	1.0293	44.1	1.344297
6, . . .	1	1.0291	88.52	11.48	3.35	8.13	.67	4.70	2.76	1.0290	42.8	1.343804
2, . . .	2	1.0296	88.53	11.47	3.45	8.02	.55	4.60	2.87	1.0288	43.1	1.343918
2, . . .	2	1.0298	88.70	11.30	3.30	8.00	.64	4.70	2.66	1.0277	42.1	1.343538
5, . . .	7	1.0283	88.82	11.18	3.20	7.98	.60	3.95	3.43	1.0260	40.5	1.342940
2, . . .	2	1.0292	88.84	11.16	3.00	8.16	.61	4.30	3.25	1.0285	41.6	1.343352
2, . . .	2	1.0292	88.93	11.07	2.95	8.12	.55	4.60	3.02	-	42.1	1.343538
2, . . .	2	1.0290	89.26	10.74	2.95	7.79	.74	4.25	2.80	1.0280	40.6	1.342978
4, . . .	5	1.0262	89.29	10.71	3.25	7.46	.55	4.00	2.91	1.0279	40.0	1.342750
2, . . .	1½	1.0293	89.41	10.59	2.55	8.04	.52	4.80	3.22	1.0290	41.8	1.343426
Highest, . .	-	1.0317	89.41	12.74	4.00	9.04	.74	4.80	4.01	1.0329	44.4	1.344408
Lowest, . .	-	1.0262	87.26	10.59	2.55	7.46	.50	3.95	2.76	1.0260	40.0	1.342750
Average, .	-	-	88.39	11.61	3.34	8.27	.61	4.45	3.21	-	-	-

It will be noted that in no case is the immersion refractometer reading lower than 40 degrees, though in one case the total solids are as low as 10.59 per cent.

Condensed Milk.

In accordance with the practice adopted during recent years the following full analyses are given of new brands only. In the reports of the last eight years will be found analyses in full of upwards of 350 samples of sweetened condensed milk, representing no less than 110 brands.

Condensed Milk.

Brand.	Total Solids (Per Cent.).	Water (Per Cent.).	Milk Solids (Per Cent.).	Cane Sugar (Per Cent.).	Milk Sugar (Per Cent.).	Proteids (Per Cent.).	Ash (Per Cent.).	Fat (Per Cent.).	Fat in Original Milk (Per Cent.).
Colonial, . . .	74.53	25.47	34.85	39.68	13.67	9.96	1.47	9.75	4.74
Blue Bell, . .	72.99	27.01	29.41	43.58	10.47	8.05	1.59	9.30	4.09
Alfalfa, . . .	73.08	26.92	32.16	40.92	12.18	9.18	1.50	9.30	3.78
Perfection, . .	77.06	22.94	30.06	47.00	11.16	8.45	1.45	9.00	4.34
Massasoit, . .	71.45	28.55	32.29	39.16	12.64	8.82	1.50	9.00	4.20
Something New, .	74.55	25.45	35.95	38.60	15.58	9.56	1.66	9.15	3.84
Dr. Hand's, . .	73.25	26.75	29.78	43.47	11.16	9.00	1.70	9.00	3.21
None Such, . .	71.72	28.28	31.03	40.69	11.97	8.61	1.50	8.95	4.16
Willow Farm, . .	68.75	31.25	30.36	38.39	10.63	9.28	1.75	8.70	3.48
Comet, . . .	73.17	26.83	28.22	44.95	9.30	8.83	1.63	8.46	3.90
Success, . . .	73.06	26.94	30.18	42.88	10.63	9.40	1.75	8.40	3.36
Rooster, . . .	74.32	25.68	28.26	45.06	10.15	9.40	1.60	8.10	3.55
Family, . . .	71.12	28.88	28.62	42.50	9.30	9.39	1.83	8.10	3.10
Merit, . . .	73.94	26.06	31.06	42.88	11.35	10.26	1.65	7.80	3.30
Owl, ...	70.24	29.76	28.34	41.88	10.89	8.31	1.36	7.80	4.02
Record, . . .	76.03	23.97	33.32	42.71	13.95	10.22	1.65	7.50	3.18
Silver, . . .	72.25	27.75	30.29	41.96	12.18	8.94	1.67	7.50	3.10
Banner, . . .	73.13	26.87	32.22	40.91	12.18	10.77	1.77	7.50	2.95

Evaporated Cream.

Brand.	Total Solids (Per Cent.).	Water (Per Cent.).	Milk Sugar (Per Cent.).	Proteids (Per Cent.).	Ash (Per Cent.).	Fat (Per Cent.)	Fat in Original Milk (Per Cent.).
Family, . . .	27.75	72.25	10.31	8.37	1.40	6.80	3.15
Silver Cow, . .	28.61	71.39	10.00	9.06	1.50	6.15	2.78
Pet, ...	-	-	-	-	1.65	9.18	3.87
Pet, ...	-	-	-	-	1.32	8.70	4.09
Borden's Peerless, .	-	-	-	-	1.64	7.80	3.32
Pet, ...	-	-	-	-	1.65	7.05	3.00
Silver Cow, . .	-	-	-	-	1.60	6.00	2.01

The following brands, which have been analyzed in full in previous years, were examined only for fat and ash: —

BRAND.	Ash (Per Cent.).	Fat (Per Cent.).	Fat in Original Milk (Per Cent.)	BRAND.	Ash (Per Cent.).	Fat (Per Cent.).	Fat in Original Milk (Per Cent.).
Rose, . .	1.65	10.20	4.34	Defiance, . .	1.32	8.10	4.65
Up to Date, .	1.63	9.60	4.12	Alfalfa, . .	1.27	8.10	4.47
Up to Date, .	1.82	9.60	3.48	Maine, . .	1.73	8.10	3.67
Dairy, . .	1.67	9.30	3.88	Vermont, . .	1.63	8.10	3.49
Chief, . .	1.70	9.15	3.76	Family, . .	1.59	8.10	3.43
Windmill, .	1.40	9.00	4.50	Rooster, . .	1.66	8.10	3.41
Merit, . .	1.73	9.00	3.60	Fern, . .	1.69	8.10	3.36
Elk, . . .	1.91	9.00	3.30	Blue Bell, .	1.68	8.10	3.33
None Such, .	2.06	9.15	3.12	Connor's, . .	2.00	7.95	2.79
Thistle, . .	1.49	8.85	4.15	Cow Boy, .	1.41	7.80	3.88
Connor's, . .	1.82	8.85	3.02	Connor's, . .	1.62	7.80	3.37
Standard, . .	1.47	8.70	4.14	Challenge, .	1.66	7.80	3.33
Gray's, . .	1.53	8.70	3.99	O'Keefe's, .	1.69	7.80	2.87
Up to Date, .	1.77	8.70	3.44	Connor's, . .	1.98	7.80	3.23
Tip Top, . .	1.82	8.70	3.35	Silver, . .	1.78	7.80	3.07
Table, . .	2.11	8.70	2.90	Lennox, . .	1.54	7.50	3.41
Nestlé's Swiss,	1.44	8.55	4.15	Silver, . .	1.68	7.50	3.12
Eagle, . .	1.24	8.40	4.30	Lennox, . .	1.76	7.50	2.98
Ruby, . .	1.49	8.40	3.94	Silver, . .	1.87	7.50	2.80
Connor's, . .	1.59	8.40	3.70	Up to Date, .	1.46	6.90	3.28
Connor's, . .	1.86	8.40	3.17	Lion, . .	1.60	6.60	2.87
Connor's, . .	1.85	8.40	3.17	Sweet Clover, .	1.35	6.15	3.20
Merit, . .	1.87	8.40	3.14	Connor's, . .	1.72	6.00	2.44
Table, . .	1.88	8.40	3.11	Connor's, . .	1.77	5.85	2.31
Connor's, . .	1.74	8.40	3.36	Table, . .	0.18	4.20	1.68
Milk Maid, .	1.73	8.25	3.30				

BUTTER.

One hundred and forty-two samples were analyzed, 17 of which were adulterated. Of these, 5 were oleomargarine and 12 renovated butter. One sample of oleomargarine was found to be colored with annatto, and 1 sample of renovated butter was preserved with boric acid.

United States Standards for Butter.

Standard butter is butter containing not less than 82.5 per cent. of butter fat.

Standard renovated or process butter is renovated or process butter containing not more than 16 per cent. of water and at least 82.5 per cent. of butter fat.

Detection of Annatto in Butter. — Treat 2 or 3 grams of the melted and filtered fat (free from salt and water) with warm dilute sodium hydroxide. After stirring, pour the mixture while warm upon a wet filter, using to advantage a hot funnel. If annatto is present the filter will absorb the color, so that when the fat is washed off by a gentle stream of water the paper will be dyed straw color. It is well to pass the warm alkaline filtrate two or three times through the fat on the paper to insure removal of the color. If after drying the filtrate the color turns pink on application of a drop of stannous chloride solution, annatto is assured.

Cheese.

Of 62 samples analyzed, 26 were found to be adulterated. The following table shows the results of the analyses of adulterated brands, and of 4 samples of good standard quality, introduced by way of comparison. The four samples of genuine cheese are numbered 1, 2, 3, and 8.

Number.	Variety.	Brand.	Solids (Per Cent.).	Water (Per Cent.).	Fat (Per Cent.).	Ash (Per Cent.).	Proteids (Per Cent.).	Pre-servative.	Remarks.
1	Camembert cheese,	-	44.05	55.95	24.00	3.56	16.49	-	
2	Swiss cheese, . .	-	67.40	32.60	36.00	3.53	27.87	-	
3	Cheddar cheese, .	-	78.11	21.89	38.00	2.40	37.71	-	
4	Soft cheese, . .	Maclaren's Imperial, . .	67.60	32.40	40.00	4.18	23.42	Boric acid.	
5	Soft cheese, . .	Royal Luncheon, ...	69 50	30.50	38.40	4.67	26.43	Boric acid.	
6	Soft cheese, . .	Canada Cream, ...	68.40	31.60	34.70	5.09	25.91	Boric acid.	
7	Soft cheese, . .	Manhattan Club, ...	-	-	30.40	-	-	Boric acid.	
8	Neufchatel cream, .	-	62.37	37.63	47.40	1.27	13.40	-	
9	Neufchatel cream, .	Worcester County M. R. B ,	37.83	62.17	15.20	1.27	21.36	-	Made from skimmed milk.
10	Neufchatel cream, .	Mountain, ...	37.27	62.73	8.20	1.69	27.38	-	Made from skimmed milk.
11	Neufchatel cream, .	Sheafe, ...	-	-	2.40	-	-	-	Made from skimmed milk.
12	Neufchatel cream, .	Heifer, ...	32.60	67.40	4.60	2.20	25.80	-	Made from skimmed milk.
13	Neufchatel cream, .	Heifer, ...	30.56	69.44	1.35	1.91	27.30	-	Made from skimmed milk and colored with a coal tar dye to conceal its inferior condition.
14	Neufchatel, . .	Crescent, ...	39.35	60.65	10.80	1.52	27.03	-	Made from skimmed milk.
15	Neufchatel, . .	Royal, ...	34.57	65.43	7.60	1.87	24.10	-	Made from skimmed milk.
16	Neufchatel, . .	Calf, ...	27.20	72.80	2.00	1.68	23.52	-	Made from skimmed milk.

United States Standards for Cheese.

Standard whole-milk cheese, or full-cream cheese, is whole-milk or full-cream cheese containing in the water-free substance not less than 50 per cent. of butter fat.

Cream cheese is cheese made from milk or cream, or milk containing not less than 6 per cent. of fat.

Determination of Fat. Modified Babcock Method. — Weigh accurately about 6 grams of the sample in a tared beaker. Add 10 cubic centimeters of boiling water, stir with the rod till the cheese softens, and, if an emulsion is formed, preferably add a few drops of strong ammonia to aid in softening and emulsionizing. Keep the beaker in hot water till the emulsion is tolerably complete and free from lumps. If the sample is a full-cream cheese, which is usually evident from its taste and appearance, a Babcock cream bottle is employed. The contents of the beaker, after cooling, are transferred to the test bottle as follows: add to the beaker about half of the 17.6 cubic centimeters of sulphuric acid regularly used for the test. Stir with the rod and pour carefully into the bottle, using the remainder of the acid in two portions for washing out the beaker. Finally proceed as in the regular Babcock test for milk. Multiply the fat reading by 18 and divide by the weight of the sample taken to obtain the per cent. of fat.

Detection of Skimmed-milk Cheese. — In a cream cheese the fat should greatly exceed the proteids. In a whole-milk cheese the per cent. of fat should at least equal that of the proteids, and is generally in excess. If the fat is considerably less than the proteids, the cheese has undoubtedly been made from skimmed milk.

A series of successful prosecutions made during the year have resulted in preventing to a large extent the mis-labelling of soft cheeses sold under the name of "Neufchatel Cheese," or "Neufchatel Cream Cheese." It had become quite common to sell in small packages under the above names the ordinary cottage cheese made from skimmed milk. There need be no uncertainty as to the meaning of the term Neufchatel when used in connection with cheese, for while, as a matter of fact, it is impossible in the American market to find samples of the imported Neufchatel cheese on account of its perishable nature, there are plenty of available analyses of French Neufchatel cheese. Thus König gives the mean of the analyses of a large number of brands of European Neufchatel cheese as 36.67 per cent. of fat. Neufchatel cheese is thus defined by the Century Dictionary: "Cream thickened by heating and then pressed in a small mold, made at Neufchatel-en-Bray in Normandy. It is considered a great delicacy." The Standard Dictionary gives the following for Neufchatel cheese: "A small, delicate cream cheese made at Neufchatel-en-Bray, France."

In one case, prosecuted in central Massachusetts for the sale of a skimmed-milk cheese, sold under the name of "Neufchatel Cream Cheese," it was ingeniously argued that the word "Neufchatel" before "Cream" had a modifying effect, as if to lower the amount of fat! This particular sample contained only 2.6 per cent. of fat.

A number of brands of soft cheese were found preserved with boric acid, and one sample was colored with a coal tar dye.

Chocolate and Cocoa.

Forty-two samples were analyzed, 20 of which were adulterated. The usual adulterants, wheat and corn starches and sugars, were found.

Published Results of Analyses of Cocoa.

Brands.	Name of Producer or Wholesaler.	Results of Analyses.
Favorite Breakfast,	John T. Connor, Boston,	Contains corn and wheat starch. Marked "absolutely pure."
Union Breakfast,	Union Grocery Company, Haverhill.	Admixture of wheat starch.
Brewster's Royal,	Brewster Cocoa Manufacturing Company, Newark, N.J.	Admixture of wheat starch.
Caracas Breakfast,	Brewster Cocoa Manufacturing Company, Newark, N.J.	Admixture of wheat starch.
Breakfast Cocoa,	Cream Chocolate Company, Chelsea.	Formula, "25 per cent. cereals." No cereals, largely cocoa shells.
Imperial Breakfast Cocoa,	Crown Chocolate Company, Chelsea.	Formula, "75 per cent. best varieties of cocoa bean, 25 per cent. cereals." Cereals as per label; cocoa is largely cocoa shells.
Health,	Lewis De Groff & Son, New York.	Admixture of wheat.
———,	Grave & Martin Co., New York.	Large admixture of wheat.
Gondar,	R. T. Erwin & Co., Philadelphia, Pa.	Large admixture of corn starch and sugar.

United States Standards.

Standard chocolate is chocolate containing not more than 3 per cent. of ash insoluble in water, 3.50 per cent. of crude fiber, and 9 per cent. of starch, nor less than 45 per cent. of cocoa fat.

Standard sweet chocolate and *standard chocolate coating* are sweet chocolate and chocolate coating containing in the sugar-and-fat-free residue no higher percentage of either ash, fiber or starch than is found in the sugar-and-fat-free residue of plain chocolate.

Standard cocoa is cocoa containing percentages of ash, crude fiber and starch corresponding to those in chocolate after correction for fat removed.

Standard sweet cocoa is sweet cocoa containing not more than 60 per cent. of sugar (sucrose), and in the sugar-and-fat-free residue no higher percentage of either ash, crude fiber or starch than is found in the sugar-and-fat-free residue of plain chocolate.

Coffee.

Six out of 106 samples examined were classed as adulterated. The worst sample, marked "Red Clover Brand," and manufactured by Darling & Co. of Troy, N. Y., contained 50 per cent. of peas, pea hulls and chicory.

Confectionery.

Twenty-four samples were examined, all of which were pure.

Cream of Tartar.

Five out of 317 samples examined were classed as adulterated, being made up of the usual mixture, with varying amounts of cream of tartar, of acid phosphate of lime, calcium sulphate and corn starch.

Flavoring Extracts.

Jamaica Ginger. — Five brands were examined, only 1 of which, made by the Walker Chemical and Extract Company of Chelsea, was condemned as adulterated. This sample contained a slight trace of ginger oil, and had no formula setting forth the nature of the compound, as required by law for such preparations, when below the standard.

Lemon Extract. — Twenty-seven samples were examined, 19 of which were classed as adulterated by reason of insufficient lemon oil and alcohol, or because the formula stating name and per cent. of ingredients was found to be incorrect. Standard lemon extract should contain 5 per cent. of lemon oil. The following brands of lemon extract were found to be adulterated: —

Published Results of Analyses of Lemon Extract.

Brand.	Name of Producer or Wholesaler.	Results of Analyses (Per Cent.).	
		Lemon Oil.	Alcohol by Volume.
Folsom's Pure,	G. A. Folsom & Co., Boston,	0.0	26.04
A. & P.,	Great Atlantic and Pacific Tea Company, New York,	0.0	-
Royal Worcester,	Royal Worcester Extract Company, Worcester,	0.12	52.62
Puritan,	R. P. Hoagland, Boston,	0.2	53.53
Pure Sovereign,	Union Pacific Tea Company, New York,	0.5	61.10
Pure,	Metras D. Vezina, Fall River,	0.8	61.99
Royal,	John Burnett & Co., Boston,	1.0	65.67
Pure Concentrated,	No address,	1.0	74.79
Regal,	Regal Extract Company, Boston,	1.3	-
Manning's,	L. W. Manning & Co., Somerville,	1.8	-
Harold's,	Harold & Co , Cambridgeport,	1.9	77.26
Favorite,	Cate & Sullivan, Fall River,	2.3	-
Miner's,	B. F. Miner, Montague,	2.4	78.22
Hull's Concentrated,	Geo. S. Hull & Co., Lowell,	3.1	85.95
Harris Pure,	Frank E. Harris, Binghampton, N. Y.,	3.3	87.85

Vanilla Extract. — Here, as in the case of lemon, one finds frequent examples of erroneous and misleading formulæ. Judging from the character of these goods it would seem as if many manufacturers assume that the presence of *any* formula upon the package is enough to comply with the law, but in many cases the statement on the label is not borne out by the analysis. Of the 25 samples examined, 12 were adulterated, represented by the following brands: —

Published Results of Analyses of Vanilla Extract.

Brand.	Names of Producer or Wholesaler.	Results of Analyses.
Harold,	Harold & Co., Cambridgeport,	Incorrect formula.
A & P.,	Great Atlantic and Pacific Tea Company, New York.	Incorrect formula.
Climax,	Climax Extract Company, Boston.	Incorrect formula.
"Compound,"	J. Smith Brockway Company, Boston.	Incorrect formula.
Hull's Compound Concentrated,	Geo. S. Hull & Co., Lowell,	Incorrect formula.
St. John's,	St. John & Co., New York,	Contains coumarin.
Perfection,	Perfection Extract Company, New York.	Contains no vanillin. A tincture of tonka.
Manning's,	L. W. Manning & Co., Somerville.	An artificial extract. No formula.

Honey.

Fifty-nine samples were examined, 24 of which were adulterated by the admixture of cane sugar or commercial glucose or both. The worst sample contained 24 per cent. of glucose.

Published Results of Analyses of Honey.

Brand.	Name of Producer or Wholesaler.	Results of Analyses.
Preferred Stock,	Martin L. Hall Co., Boston,	Admixture of 33 per cent. cane sugar.
- -	Huntington Maple Syrup and Sugar Company, Providence, R. I.	Admixture of 5 per cent. commercial glucose.
Pure California, with granulated sugar to prevent crystallization.	- -	Thirty-two per cent. cane sugar. Formula not in accordance with law.
Wild Rose California,	San Diego Company, San Francisco, Cal.	Admixture of glucose and cane sugar.
White Clover Extra Fine,	- -	Formula, "25 per cent. extracted honey, 75 per cent. common syrup." Eighty-four per cent. glucose syrup colored with a coal tar dye.
Clover Blossom,	Clover Honey Company, San Francisco, Cal.	Admixture of glucose and cane sugar.
White Sage California,	Mountain Honey Company, San Francisco, Cal.	Admixture of glucose and cane sugar.
Orange Blossom,	Ayer Preserving Company, Ayer, Mass.	Admixture of glucose and cane sugar.
Choice Strained Honey. "Warranted strictly pure."	Ayer Preserving Company, Ayer, Mass.	Admixture of cane sugar.
Orange Blossom Honey. "Guaranteed strictly pure."	Ayer Preserving Company, Ayer, Mass.	Admixture of glucose.
Mountain Laurel,	Manhattan Dairy Company, Boston,	Admixture of glucose.

Lard.

Fifty-one samples were examined, 30 of which were adulterated with either cottonseed oil or beef stearine, or both.

Maple Sugar and Syrup.

Of the sugar samples, 4 out of 13 were found adulterated, and of syrups, 14 out of 57. The adulterant in all cases was refined cane sugar. The

ash of pure maple syrup should not be less than 0.35 or 0.40 per cent., a lower ash indicating the admixture of refined cane sugar. On the other hand, the addition of molasses or brown sugar stock would tend to raise the ash far above the average for pure maple, as well as to increase the reducing sugars. A high reducing sugar, say over 5 per cent., while suspicious, should not be assumed as conclusive evidence in itself of molasses sugars, since old and inferior samples of maple sugar and syrup are sometimes found with reducing sugar abnormally high. It is frequently possible to identify brown or molasses sugar, especially when it forms the larger portion of the alleged maple sugar or syrup, by the physical sense of taste. When the perfectly characteristic taste of brown or molasses sugar, or of drip or sugar house syrup, so far predominates over the maple flavor as to be unmistakable, especially in cases where the maple flavor is entirely lacking, one need have little hesitation in condemning the product. There seems to be no good reason why the sense of taste, if properly cultivated, and with its limitations recognized, should not be entitled, if used with discretion, to as much consideration as the other senses in forming an opinion.

A more positive test for refined cane sugar and syrup, and one which we have used with good results, has been devised by Julius Hortvet. This method has recently been submitted for adoption among the food methods of the Association of Official Agricultural Chemists, and depends on the principle that the volume of the precipitate, by treatment of the sugar solution or syrup under fixed conditions with alumina cream and subacetate of lead, varies with the amount of refined sugar present. Hortvet's apparatus consists of peculiarly shaped graduated tubes, adapted by means of wooden holders to be carried in the shields of an ordinary centrifuge.

The following brands of maple syrup were advertised as adulterated: —

Published Results of Analyses of Maple Syrup.

Brands.	Name of Producer or Wholesaler.	Results of Analyses.
——,	John T. Connor, Boston,	Admixture of sugar other than maple.
——,	Eastern Grocers' Specialty Company, Chelsea, Mass.	Admixture of sugar other than maple.
Preferred Stock,	Martin L. Hall Co., Boston,	Admixture of sugar other than maple.
——,	American Pickling Company, Providence, R.I.	Admixture of sugar other than maple.
Gold Leaf,	Huntington Maple Syrup and Sugar Company, Providence, R.I.	Admixture of sugar other than maple.
Whitcher's,	Ayer Preserving Company, Ayer, Mass.	Admixture of sugar other than maple.
Merrimac,	Riverside Preserving Company, Lowell, Mass.	Admixture of sugar other than maple.
Green Mountain,	National Maple Sugar Association, Waitsfield, Vt.	Admixture of sugar other than maple.
——,	R. Foulsham, Boston,	Admixture of sugar other than maple.

Molasses.

One hundred and seven samples were examined, of which 4 were adulterated. The worst sample contained 33 per cent. of commercial glucose. One sample, labelled "Dove Brand Fancy Refined New Orleans Molasses," put out in cans by the T. H. Alexander Co. of New Orleans, La., was found to contain 45 per cent. of commercial glucose. The can bore a formula as follows: "Molasses Compound. 75 per cent. pure open kettle molasses, into which 25 per cent. pure grape sugar has been dissolved, then thoroughly refined."

Spices.

Allspice. — One hundred and eighty-four samples were analyzed, 9 of which were adulterated. Adulterants were wheat, exhausted ginger, sweepings and dirt.

United States standard allspice is allspice containing not less than 8 per cent. of quercitannic acid, not more than 6 per cent. of total ash, not more than .5 per cent. of ash insoluble in hydrochloric acid, and not more than 25 per cent. of crude fiber.

Cassia. — Six out of 227 samples were adulterated. The worst sample contained 30 per cent. of corn, nut shells and turmeric.

United States standard cinnamon or cassia is cinnamon or cassia containing not more than 8 per cent. of total ash, and not more than 2 per cent of sand.

Cayenne. — But 1 sample of the 61 examined was found to be adulterated. This contained a small admixture of exhausted ginger.

United States standard cayenne pepper is cayenne pepper containing not less than 15 per cent. of non-volatile ether extract, not more than 6.5 per cent. of total ash, not more than .5 per cent. of ash insoluble in hydrochloric acid, not more than 1.5 per cent. of starch by the diastase method, and not more than 28 per cent. of crude fiber.

Cloves. — Two hundred and eight samples were analyzed, 21 of which were adulterated with clove stems and starch.

United States standard cloves are cloves containing not less than 10 per cent. non-volatile ether extract, not less than 12 per cent. of quercitannic acid, not more than 8 per cent. of total ash, not more than .5 per cent. of ash insoluble in hydrochloric acid, and not more than 10 per cent. of crude fiber.

Ginger. — Nine out of 224 samples analyzed were found adulterated with turmeric. One sample contained 20 per cent. of turmeric.

United States standard ginger is ground or whole ginger containing not less than 42 per cent. nor more than 46 per cent. of starch by direct inversion, not more than 8 per cent. of crude fiber, not more than 8 per cent. of total ash, not more than 1 per cent. of lime, and not more than 3 per cent. of ash insoluble in hydrochloric acid.

Mustard. — Two hundred and fifty samples were analyzed, of which 66 were classed as adulterated, by reason of the presence of foreign starches, turmeric and added mustard hulls.

One sample contained 80 per cent. of wheat and turmeric; another 70 per cent. of wheat, corn, buckwheat and turmeric.

United States standard ground mustard is mustard containing not more than 2.5 per cent. of starch by the diastase method and not more than 8 per cent. of total ash.

Mace. — Thirty-one samples were examined, 18 of which were adulterated. While the most common adulterant of these spices is found to be wild mace, or Bombay mace, wheat and corn starch are also frequently found. One sample consisted of at least 80 per cent. of corn, wheat and wild mace.

The refractive indices of the fixed oils of various species of pure as well as of Bombay mace, as determined by Lythgoe, are as follows: —

	^{n}D at 25° C.
Banda mace (1),	1.4848
Banda mace (2),	1.4747
Banda mace (3),	1.4829
Batavia mace (1),	1.4893
Batavia mace (2),	1.4975
Papua mace (1),	1.4816
Papua mace (2),	1.4795
West Indian mace (1),	1.4766
Bombay mace (1),	1.4615
Bombay mace (2),	1.4633

At room temperature the fixed oil of Bombay is a thick and viscous fat, while that of Penang and other maces is a thin oil.

United States standard mace is mace containing not less than 20 nor more than 30 per cent. of non-volatile ether extract, not more than 3 per cent. of total ash, not more than .5 per cent. of ash insoluble in hydrochloric acid, and not more than 10 per cent. of crude fiber.

Nutmeg. — Twelve samples were examined, all of which were pure.

United States standard nutmegs, ground or unground, are nutmegs containing not less than 25 per cent. of non-volatile ether extract, not more than 5 per cent. of total ash, not more than .5 per cent. of ash insoluble in hydrochloric acid, and not more than 10 per cent. of crude fiber.

Pepper. — Forty-three adulterated samples were found, out of 376 examined. Usual adulterants were buckwheat, corn starch and olive stones. One sample contained 20 per cent. of buckwheat, another 80 per cent. of corn starch.

United States standard black pepper is black pepper free from added pepper shells, pepper dust and other pepper by-products, and containing not less than 6 per cent. of non-volatile ether extract, not less than 22

per cent. of starch by the diastase method, not less than 28 per cent. of starch by direct inversion, not more than 7 per cent. of total ash, not more than 2 per cent. of ash insoluble in hydrochloric acid, and not more than 15 per cent. of crude fiber. One hundred parts of the non-volatile ether extract contain not less than 3.25 parts of nitrogen.

United States standard white pepper is white pepper containing not less than 6 per cent. of non-volatile ether extract, not less than 53 per cent. of starch by the diastase method, not less than 56 per cent. of starch by direct inversion, not less than 4 per cent. of total ash, not more than .5 per cent. of ash insoluble in hydrochloric acid, and not more than 5 per cent. of crude fiber. One hundred parts of the non-volatile ether extract contain not less than 4 parts of nitrogen.

The following list of adulterated brands of spices was compiled from the monthly bulletins published during the year. It should be noted that this list comprises but a small part of the spices found adulterated, most of the adulterated samples being naturally bulk goods.

Published Results of Analyses of Spices.

Character of Sample.	Brand.	Name of Producer or Wholesaler.	Results of Analyses.
Cassia,	- -	Frank Stonestreet, East Boston,	Exhausted cassia.
Cinnamon,	- -	Weisman Ward & Co., Albany, N. Y.	Thirty per cent corn starch, nutshells and turmeric.
Cloves,	- -	Frank Stonestreet, East Boston,	Large excess of stems and sweepings.
Cloves,	- -	Great Atlantic and Pacific Tea Company.	Large excess of stems, ginger and sweepings.
Ginger,	- -	C. N. Fort & Co., Albany, N. Y.,	Turmeric and foreign starch.
Mace,	O'Keeffe's Choice,	O'Keeffe, Boston,	Contains wild mace.
Mace,	"Blue Ribbon Penang,"	Austin Nichols & Co., New York,	Contains wild mace.
Mace,	Hatchet,	Twitchell Champlin Co., Boston,	Contains wild mace.
Mace,	- -	Hatton Bros. & Johnson, Lynn, Mass.	Contains wild mace.
Mustard,	O'Keeffe's English,	M. O'Keeffe, Boston,	Largely mustard hulls.
Mustard,	Pure Sovereign,	Union Pacific Tea Company,	Admixture of starch.
Mustard,	- -	W. H. Gilbert & Co., Springfield,	Large admixture of starch and turmeric.
Mustard,	Ancho,	Ancho Spice Mills, New York,	Large admixture of turmeric.
Mustard,	Genuine English,	B. Fischer & Co., New York,	Colored with turmeric; excess of hulls.
Mustard,	- -	Chas. H. Wigmore, Cambridge,	Colored with turmeric; excess of hulls.
Pepper,	- -	Challenge Mills,	Seventy per cent. corn starch.
Pepper,	- -	Bacon, Stickney & Co., Albany, N. Y.	Twenty per cent. buckwheat.
Pepper,	- -	M. O'Keeffe, Boston,	Added pepper shells.
Pepper,	- -	W. G. Baker, Springfield, Mass.,	Added pepper shells.
Pepper,	- -	Challenge Mills,	Added pepper shells.
Pepper,	- -	Chas. H. Wigmore, Cambridge,	Added pepper shells.

TEA.

Twenty-eight samples of tea were examined, all of which were genuine.

VINEGAR.

Fifty-three out of 99 samples analyzed were found to be adulterated.

There is no food product in which competition and cheap methods of manufacture have resulted so disastrously to the quality of the substance as in the case of cider vinegar. Where formerly the farmer by the slow fermentation process and from pure cider produced all the vinegar consumed, and obtained a good price for it, now the price of so-called cider vinegar is so low that the self-respecting farmer can hardly afford to enter the race. Much skill has been shown of late in the manufacture of spurious "cider" vinegar with a view to deceiving the analyst, so that it is incumbent on him to know very thoroughly the composition of cider vinegar, and especially of the various qualities or characteristics which serve to distinguish it from the factitious variety.

In addition to the 99 samples reported above, which were collected by the inspectors in the regular routine of their work, 22 samples of cider vinegar of known purity have been analyzed in full with a view to suggesting helpful standards in addition to those which for twenty years have prevailed in Massachusetts for acidity and total solids.

The list comprises (1) samples made in the laboratory, (2) samples made by farmers, and (3) samples from reputable manufacturers made both by the slow and by the generator processes, all those obtained from outside the laboratory being furnished for the purpose of analysis with a guarantee that nothing but apple juice was used in their manufacture.

Determinations were made of acetic acid, solids, ash, alkalinity of the ash, soluble and insoluble phosphates, reducing sugars both before and after inversion, polarization, and malic acid. Percentage of ash in solids, percentage of reducing sugars in solids, ratio of soluble to total phosphates, and alkalinity of one gram of ash have been calculated.

Cider Vinegar of Known Purity.

Number.	Acetic Acid (Per Cent.).	Total Solids (Per Cent.).	Ash (Per Cent.).	Alkalinity of Ash of 100 Grams of Vinegar (cc. N/10 Acid).	Soluble P_2O_5 in Ash of 100 Grams of Vinegar (mg.).	Insoluble P_2O_5 in Ash of 100 Grams of Vinegar (mg.).	Reducing Sugars (Dextrose) before inversion (Per Cent.).	Reducing Sugars (Dextrose) after inversion (Per Cent.).	Polarization (degrees Ventzke 200 mm.).	Lead Acetate Test for Malic Acid.	Calcium Chloride Test for Malic Acid.	Malic Acid (Per Cent.).	Per Cent. Ash in Total Solids.	Per Cent. Reducing Sugars in Total Solids.	Ratio of Soluble P_2O_5 to Total P_2O_5.	Alkalinity of 1 Gram of Ash (cc. N/10 Acid).
1,	5.86	2.00	.20	22.2	25.0	22.7	.23	.23	—0.9	Precipitate.	Precipitate.	-	10.0	11.5	51.7	111
2,	5.78	2.86	.29	26.2	31.7	31.5	.34	.34	—3.6	Precipitate.	Precipitate.	-	10.0	11.9	50.1	90
3,	5.68	2.80	.38	34.6	19.5	14.0	.24	.24	—1.3	Precipitate.	Precipitate.	.07	13.6	8.6	57.6	94
4,	5.63	2.04	.36	31.1	20.0	14.0	.15	.15	—1.1	Precipitate.	Precipitate.	-	17.6	7.4	60.6	85
5,	5.48	2.35	.29	26.6	12.1	12.1	.23	.24	—2.1	Precipitate.	Precipitate.	-	12.3	10.2	50.0	92
6,	5.44	2.75	.40	36.1	16.2	6.5	.23	.23	—1.1	Precipitate.	Precipitate.	.09	14.5	8.4	71.4	90
7,	5.21	2.70	.42	30.2	16.2	8.4	.24	.24	—1.1	Precipitate.	Precipitate.	.09	15.6	8.9	61.8	72
8,	5.12	2.04	.21	26.7	14.0	12.1	.22	.22	—1.6	Precipitate.	Precipitate.	-	10.3	10.8	53.2	122
9,	4.84	3.20	.32	31.0	14.0	12.6	.51	.53	—1.1	Precipitate.	Precipitate.	.08	10.0	16.6	52.6	97
10,	4.81	3.00	.34	30.1	19.0	17.3	.32	.32	—1.8	Precipitate.	Precipitate.	-	11.3	10.7	52.3	89
11,	4.81	2.45	.38	28.2	24.7	17.6	.34	.34	—0.9	Precipitate.	Precipitate.	-	15.5	13.9	57.0	74
12,	4.80	2.55	.37	30.3	15.8	7.8	.21	.23	—1.1	Precipitate.	Precipitate.	.09	14.5	9.0	66.9	82
13,	4.55	2.19	.37	31.1	18.6	18.1	.26	.26	—1.2	Precipitate.	Precipitate.	.14	16.9	12.4	50.4	84
14,	4.52	3.14	.41	28.2	21.7	19.0	.28	.28	—0.7	Precipitate.	Precipitate.	.10	13.0	8.9	68.4	69
15,	4.52	2.69	.42	29.0	24.9	21.7	.23	.23	—0.6	Precipitate.	Precipitate.	-	15.6	8.6	53.5	69
16,	4.51	2.15	.41	33.9	16.7	16.3	.16	.16	—0.4	Precipitate.	Precipitate.	.15	19.0	7.5	50.3	80
17,	4.50	2.20	.39	35.1	18.9	11.6	.16	.16	—0.3	Precipitate.	Precipitate.	.16	17.7	7.3	56.9	90
18,	4.28	1.95	.26	32.4	17.2	12.1	.18	.18	—0.7	Precipitate.	Precipitate.	-	13.3	9.2	58.6	125
19,	4.27	2.23	.40	30.8	17.2	15.3	.18	.18	—0.5	Precipitate.	Precipitate.	-	17.9	8.1	52.9	77
20,	4.02	2.98	.32	29.8	16.2	13.5	.29	.29	—0.9	Precipitate.	Precipitate.	-	10.7	9.7	53.9	93
21,	3.94	2.74	.37	32.4	17.1	12.0	.25	.26	—1.8	Precipitate.	Precipitate.	.16	13.5	9.5	58.8	85
22,	3.92	1.84	.25	26.4	16.8	16.7	.25	.25	—2.7	Precipitate.	Precipitate.	.08	13.6	13.6	50.1	105
Highest,	5.86	3.20	.42	36.1	31.7	31.5	.51	.53	—3.6	-	-	.16	19.0	16.6	66.9	125
Lowest,	3.92	1.84	.20	22.2	12.1	6.5	.15	.15	—0.3	-		.08	10.0	7.3	50.0	69
Average,	4.84	2.49	.34	29.7	19.2	15.6	.25	.25	—1.3	-	-	.11	13.8	10.7	56.3	90

The methods used in making the above analyses are given in full in the Journal of the American Chemical Society, volume 26 (1904), page 375.*

Malic Acid. — In the analyst's report of last year is described the calcium chloride test for malic acid in vinegar, which in its simplest form is fairly conclusive in the absence of dextrine and sulphates. To positively confirm the presence of malates, filter off the precipitate that occurs with the addition of the alcohol in the above test, dry out the alcohol therefrom (to prevent subsequent explosion of ethyl nitrite), dissolve in dilute nitric acid and evaporate to dryness over the boiling water bath. This treatment transforms the calcium malate to calcium oxalate. Boil with sodium carbonate solution for a few minutes to decompose the salt, filter from the precipitated calcium carbonate, make the filtrate acid with acetic acid and add a solution of calcium sulphate. A precipitate of calcium oxalate at this stage confirms the presence of malic acid in the vinegar. Calcium sulphate solution is used so that, if sulphates were present, a precipitate of calcium sulphate would not occur and thus vitiate the test.

Importance of making Both the Calcium Chloride and Lead Acetate Tests. — A sample of vinegar made from partly exhausted apple pomace will sometimes give a test for malic acid with the calcium chloride method where only a turbidity would occur with the lead acetate. This is due to the fact that the apple pomace used has still retained some of the malic acid, and that the lead acetate test is less delicate than the calcium chloride test because lead malate is slightly soluble in acetic acid. In a pure cider vinegar there should always be sufficient malic acid present to give a distinct precipitate with lead acetate, and such a vinegar should respond in a perfectly normal manner to both tests. If either test fails the sample may safely be condemned.

Determination of Malic Acid. — This was the method employed in making the above analyses. One hundred grams of vinegar were treated with 10 cubic centimeters of 10 per cent. calcium chloride and made alkaline with ammonium hydroxide. After standing for one hour the solution was filtered and the precipitate washed with water. The filtrate was evaporated to about 25 cubic centimeters and 3 volumes of 95 per cent. alcohol were added, the solution heated to boiling and filtered on an ashless filter paper. The separated calcium malate was washed with hot 75 per cent. alcohol, and burned in a platinum crucible. The ash was dissolved in 35 cubic centimeters of tenth-normal hydrochloric acid by boiling, and the excess of acid determined by titrating with tenth-normal sodium hydroxide, using phenolphthalein as an indicator. The number of cubic centimeters of tenth-normal acid used up, multiplied by 0.0067, gives the percentage of malic acid in the sample.

Suggested Standards. — Pure cider vinegar should contain at least 4.50 per cent. of acetic acid, and at least 2 per cent. of cider vinegar solids.

* Cider Vinegar and Suggested Standards of Purity, by Albert E. Leach and Herman C. Lythgoe.

The ash should constitute at least 6 per cent. of the solids. The alkalinity of 1 gram of ash should be equivalent to at least 65 cubic centimeters of tenth-normal acid. At least 50 per cent. of the phosphates in the ash should be soluble in water. The reducing sugars should be the same in amount after as before inversion, and should not exceed 25 per cent. of the solids. The polarization, expressed in terms of 200 millimeters of undiluted vinegar, should lie between —0.1° and —4.0° Ventzke. Malic acid should be indicated by both the calcium chloride and lead acetate test.

A standard for malic acid is desirable, but before suggesting such, a larger number of determinations should be made than those hitherto recorded.

Routine Examination of Vinegar for Adulteration. — In determining whether or not an alleged vinegar is spurious, it is rarely necessary for the public analyst to make a complete analysis. Aside from the determination of acidity and total solids, by far the most important tests consist in the polarization and in the calcium chloride and lead acetate tests for malic acid. It is rare that spurious vinegar will fail of detection by at least one of these tests. Only in doubtful cases is it necessary to go farther. It is well, however, to be able in some cases to confirm one's judgment by added proof, and where litigation is involved, a complete analysis may be helpful.

The following table is a summary of the results of analyses of 43 samples of cider vinegar examined during the year and found to be above the standard: —

Cider Vinegar.

	Acid (Per Cent.).	Solids (Per Cent.).	Polarization (200 mm.).
Highest, ...	7.34	3.34	—3.5
Lowest, ...	4.50	2.00	—0.3
Average, ...	4.88	2.37	—2.0

The following table shows the results of the analyses of 19 samples of what were probably cider vinegar, but which were below the Massachusetts standard of acids, or solids, or both.

Cider Vinegar not of Good Standard Quality.

Acid (Per Cent.).	Solids (Per Cent.).	Polarization 200 mm.).	Malic Acid.		Acid (Per Cent.).	Solids (Per Cent.).	Polarization 200 mm.).	Malic Acid.	
			Lead Acetate.	Calcium Chloride.				Lead Acetate.	Calcium Chloride.
5.10	1.52	—0.8	Precipitate.	Precipitate.	4.44	2.17	—1.7	Precipitate.	Precipitate.
4.88	1.96	—1.7	Precipitate.	Precipitate.	4.44	1.70	—1.1	Precipitate.	Precipitate.
4.56	1.52	—1.1	Precipitate.	Precipitate.	4.40	2.05	—1.0	Precipitate.	Precipitate.
4.48	2.69	—1.6	Precipitate.	Precipitate.	4.38	2.67	—3.6	Precipitate.	Precipitate.
4.48	1.94	—1.6	Precipitate.	Precipitate.	4.36	1.73	0.0	Precipitate.	Precipitate.
4.46	2.50	—0.8	Precipitate.	Precipitate.	4.30	2.10	—1.4	Precipitate.	Precipitate.
4.46	1.46	—0.3	Precipitate.	Precipitate.	4.20	2.43	—3.0	Precipitate.	Precipitate.
4.44	2.34	—2.2	Precipitate.	Precipitate.	3.90	2.80	—3.0	Precipitate.	Precipitate.
4.44	2.24	—1.8	Precipitate.	Precipitate.	3.54	2.40	—2.8	Precipitate.	Precipitate.
4.44	2.20	—2.4	Precipitate.	Precipitate.	-	-	-	-	-

The following are the analyses of 31 samples sold for cider vinegar, which were pronounced to be not the exclusive product of pure apple cider : —

Vinegar not the Exclusive Product of Pure Apple Cider.

Acid (Per Cent.).	Solids (Per Cent.).	Polarization (200 mm.).	Malic Acid.		Color.
			Lead Acetate.	Calcium Chloride.	
5.56	1.62	+1.2	Precipitate, . .	Precipitate, . .	-
5.54	0.83	+0.1	Precipitate, . .	Precipitate, . .	-
5.52	2.60	−2.5	No precipitate, .	No precipitate, .	-
5.02	2.31	+4.2	Precipitate, . .	No precipitate, .	Caramel.
4.94	3.00	+4.4	Precipitate, . .	Precipitate, . .	-
4.88	2.47	+5.6	Precipitate, . .	Precipitate, . .	Caramel.
4.88	0.15	+1.0	No precipitate, .	-	Caramel.
4.86	2.20	−2.6	Precipitate, . .	-	Caramel.
4.80	2.72	0.0	No precipitate, .	-	Caramel.
4.80	2.20	+8.3	Precipitate, . .	-	Caramel.
4.76	1.76	0.0	Slight precipitate,	No precipitate, .	-
4.74	2.29	−1.7	Precipitate, . .	-	Caramel.
4.72	2.29	+1.6	Precipitate, . .	-	-
4.72	1.89	−1.7	No precipitate, .	-	-*
4.68	2.91	−5.7	Precipitate, . .	Precipitate, . .	-†
4.66	1.32	+0.2	Precipitate, . .	-	-
4.64	0.35	0.0	No precipitate, .	-	Caramel.
4.63	0.47	0.0	No precipitate, .	No precipitate, .	Caramel.
4.62	2.80	+0.3	Precipitate, . .	No precipitate, .	-
4.60	2.63	+4.0	No precipitate, .	-	Caramel.
4.60	0.80	+0.4	Precipitate, . .	Precipitate, . .	Caramel.
4.58	2.40	−1.5	Precipitate, . .	Precipitate, . .	Caramel.
4.44	1.99	−2.3	Slight precipitate,	No precipitate, .	-
4.42	2.03	−2.4	Slight precipitate,	No precipitate, .	-
4.42	2.10	+10.0	Precipitate, . .	-	Caramel.
4.38	3.10	+1.3	Precipitate, . .	-	-
4.38	0.40	+0.8	No precipitate, .	-	Caramel.
4.38	0.37	+0.2	No precipitate, .	No precipitate, .	Caramel.
4.20	2.32	−0.9	Precipitate, . .	-	-
4.16	0.42	0.0	No precipitate, .	No precipitate, .	Caramel.
4.14	0.60	0.0	Precipitate, . .	-	Caramel.

* Ash, .25 per cent.; alkalinity of ash, 13; soluble, P_2O_5 13 mg.; insoluble P_2O_5 14 mg.
† Solids re-inforced with boiled cider.

One brand sold under the name of "Massachusetts Standard Vinegar," put out by Fearnley & Sidebotham, Fall River, Mass., was found to consist of spirit vinegar, colored with caramel in violation of the law.

Canned Goods.

Four samples were analyzed, 2 of which were found to be adulterated. Both of the latter samples were canned peas. One was branded "Rose Bud Early June Peas," canned by the Rose Bud Company of Baltimore. These proved to be soaked goods, and were not labelled as such. The other sample was labelled "Petits Pois, extra fine, artificially colored," put out by Guilliamey Fils. The name and amount of color were not specified, but the color proved to be copper sulphate, there being the equivalent of .146 gram of copper per can.

Miscellaneous Food.

Under this heading were included 230 samples of food, 118 of which were classed as adulterated. Samples of the following were examined and found to be pure: arrowroot, breakfast cereal, buttermilk, celery salt, codfish, cornmeal, corn starch, cider jelly, curry powders, dessert mixtures, gelatine, gelatine mixtures, German mustard, "Jell-O," lemonade powder, magic yeast, milk shake, orangeade powder, oleomargarine, paprika, peanut butter, prepared mustard, salad oil, soda, table sauce and tapioca.

Baking Powder. — Of 11 samples examined, 6 were classed as adulterated because they did not conform to the law requiring the names of ingredients to be plainly marked on the can. Two brands of alum-phosphate powder, which contained no formula in accordance with the law, were put out by the Pilgrim Baking Powder and the Boston Baking Powder companies, both of Boston. Another brand, of similar composition, was marked "Dry Yeast" and was the product of R. B. Davis of New York.

Cereal Coffee. — Five samples were examined, 2 of which were condemned as containing coffee. Both of these were branded "Old Grist Mill Wheat Coffee."

Cider. — Three out of 5 samples examined were found to contain salicylic acid. One brand, labelled "Pure Russet Cider," made by the Copeland Farm Cider Mills of Milton, was thus preserved.

Cream. — Four samples of heavy bottled cream were examined, 1 of which was found to be preserved with formaldehyde.

Ginger Ale. — Twelve samples were examined, 4 of which were pronounced adulterated on account of the presence of preservative. "Wheaton's Ginger Ale" was found to contain salicylic acid, and the "Cliquot Club" to have benzoic acid.

Grape Juice. — Six out of 13 samples analyzed were found preserved with salicylic acid.

Jams and Jellies. — One hundred and three samples of these preparations were examined, 75 of which were found to be adulterated. With the possible exception of flavoring extracts, no class of preparations give more trouble to the enforcers of the law than the so-called compound jams and jellies. The composition of an average 10-cent jar of raspberry jam is somewhat as follows: apple stock (often from the cores and parings of apple canneries), 30 per cent.; raspberry fruit (often the residue from high-grade jelly pressings), 20 per cent.; cane sugar, 15 per cent.; and commercial glucose, 35 per cent. Such a mixture is most frequently colored with a coal tar dye, and preserved with benzoic or salicylic acid. This jar of raspberry jam retails at 10 cents. Its pure prototype, put up according to the housewife's formula, with nothing but pure raspberry juice and cane sugar, would cost to the consumer at least two and a half times that price.

Under the law of Massachusetts such a mixture can be sold, if it has plainly marked on every package the name and per cent. of its ingredients. While the use of the formula for this class of foods is becoming more and more common, many of the formulæ are misleading, either by erroneous statements, or by their indistinctness. Following is a list of condemned brands of jams and jellies published during the year: —

Published Results of Analyses of Jams and Jellies.

Character of Samples.	Brand.	Name of Wholesaler or Producer.	Results of Analyses.
Raspberry jam,	-	Ayer Preserving Company, Ayer, Mass.,	Preserved with benzoic acid. No formula.
Raspberry jam,	-	Curtice Brothers, Rochester, N. Y.,	Preserved with benzoic acid. No formula.
Strawberry jam,	-	Williams Bros. & Charboneau, Detroit, Mich.,	Preserved with benzoic acid. No formula.
Wild raspberry jam,	-	F. P. Adams & Co., Boston, Mass.,	Preserved with benzoic acid. No formula.
Wild strawberry jam,	-	F. P. Adams & Co., Boston, Mass.,	Preserved with salicylic acid. No formula.
Strawberry jam, pineapple preserves, raspberry jam,	-	Ideal Preserving Company, Boston, Mass.,	Preserved with benzoic acid. Not in formula.
Strawberry jam, raspberry jam,	-	Haskell Adams & Co., Boston, Mass.,	Preserved with benzoic acid. Not in formula.
Strawberry jam, raspberry jam,	-	Logan & Johnson, Boston, Mass.,	Preserved with benzoic acid. Not in formula.
Raspberry jam,	Winner,	-	Preserved with benzoic acid. Not in formula.
Raspberry jam,	-	Ideal Preserving Company, Boston, Mass.,	Preserved with benzoic and salicylic acids. Not in formula.
Cherry preserves, peach preserves,	-	Ayer Preserving Company, Ayer, Mass.,	Preserved with benzoic and salicylic acids. Not in formula.
Apricot preserves, damson preserves,	Burns' Fresh Fruit Jams.	Ayer Preserving Company, Ayer, Mass.,	Preserved with benzoic acid and colored with a coal tar dye. Formula concealed.
Raspberry jam,	Preferred Stock,	Martin L. Hall Co., Boston, Mass.,	Preserved with salicylic acid and colored with a coal tar dye. No formula.
Raspberry jam,	-	P. J. Ritter Conserve Company, Philadelphia, Pa.,	Preserved with salicylic acid and colored with a coal tar dye. No formula.
Strawberry jam, red currant jelly,	-	E. T. Cowdrey & Co., Boston, Mass.,	Colored with a coal tar dye. No formula.
Raspberry jam,	-	Princess Conserve Company, Camden, N. J.,	Colored with a coal tar dye. Not in formula.
Wild raspberry jam, wild strawberry jam,	Star,	-	Colored with a coal tar dye. Not in formula.
Strawberry preserves,	Highland,	The Williams Brothers, Detroit, Mich.,	Colored with a coal tar dye. Not in formula.
Red raspberry jam,	-	Williams Bros. & Charboneau, Detroit, Mich.,	Colored with a coal tar dye. No formula.
Strawberry jelly, raspberry jelly, currant jelly,	-	Ayer Preserving Company, Ayer, Mass.,	Colored with a coal tar dye to conceal its inferior condition.

Published Results of Analyses of Jams and Jellies — Concluded.

Character of Samples.	Brand.	Name of Wholesaler or Producer.	Results of Analyses.
Strawberry jelly, raspberry jelly,	Renwick,	Renwick Preserving Company, New York,	Colored with a coal tar dye to conceal its inferior condition.
Strawberry jelly, currant jelly,	Home Made,	Crystal Conserve Company, New York,	Colored with a coal tar dye to conceal its inferior condition.
Apple jelly,	-	The Grocers Preserving Company, Boston, Mass.,	Colored with a coal tar dye to conceal its inferior condition.
Currant flavored jelly,	-	Lutz & Schramm Co., Allegheny, Pa.,	Colored with a coal tar dye to conceal its inferior condition.
Strawberry jelly, raspberry jelly,	Quaker,	John Boyle Co., Baltimore, Md.,	Colored with a coal tar dye to conceal its inferior condition.
Raspberry jam,	-	Haskell Adams & Co., Boston, Mass.,	Admixture of apple stock, artificially colored. Not correctly labelled.
Pineapple jelly,	-	Twitchell Champlin Co., Portland, Me.,	Chiefly apple stock. No formula.
Quince jelly,	-	Grocer's Preserving Company, Boston, Mass.,	Chiefly apple stock. No formula.
Strawberry jam, plum jam,	Eagle,	Anderson Food Company, Camden, N. J.,	Glucose greatly in excess of amount stated.

Halibut. — A sample of this fish was brought in for analysis, having caused several cases of serious illness. It was found to be badly decomposed.

Ice Cream. — One sample of this food was found to contain formaldehyde.

Lime Juice. — Nine samples were analyzed, 8 of which were adulterated, either by reason of insufficient citric acid, or on account of the presence of one or more preservatives or coloring matter without the proper formula. The following brands were found adulterated: —

Lime Juice.

Brand.	Citric Acid (Per Cent.).	Preservatives and Color.
Bee,	4.68	Benzoic acid.
Montego,	2.19	- -
Cole & Smith,	3.36	Salicylic and sulphurous acids, colored.
Plymouth Rock,	3.44	Sulphurous acid.
O'Keeffe's,	3.06	Salicylic acid.
T. W. Stowers,	2.86	Sulphuric acid.

The presence of sulphuric acid in the last brand was doubtless due to the oxidation of sulphurous acid used as a preservative.

Orange Phosphate. — A sample of Henderson's Orange Phosphate, made by Henderson & Co. of New York and Boston, was found to be artificially colored, and to contain no phosphate.

Pastry Spice. — A sample sold under this name was found to contain a mixture of various spices with large quantities of wheat and corn starch.

Summary of Food Statistics, Exclusive of Milk.

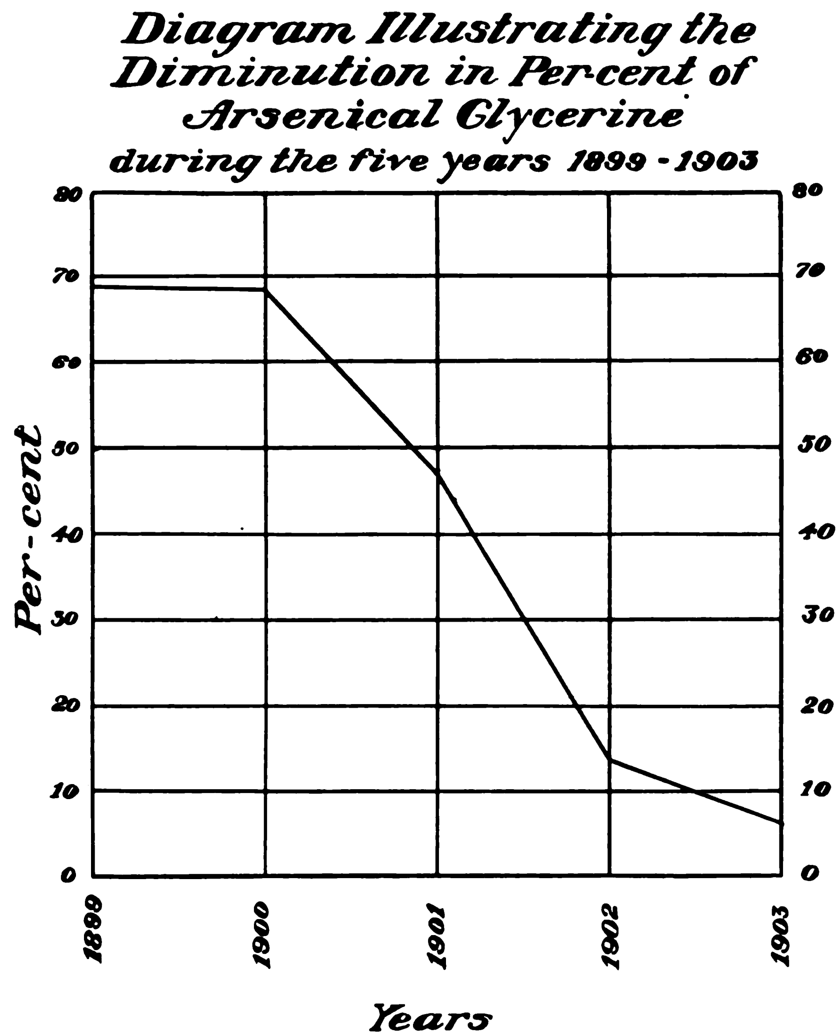
	Genuine.	Adulterated.	Total.	Per Cent. of Adulteration.		Genuine.	Adulterated.	Total.	Per Cent. of Adulteration.
Allspice,	175	9	184	4.8	Ginger,	235	9	244	3.7
Butter,	125	17	142	11.9	Honey,	35	24	59	40.7
Canned goods,	4	2	6	33.3	Lard,	21	30	51	58.8
Cassia,	221	6	227	2.6	Mace,	13	18	31	58.1
Cayenne,	60	1	61	1.6	Maple sugar,	9	4	13	30.8
Cheese,	36	26	62	41.9	Maple syrup,	43	14	57	24.5
Chocolate and cocoa,	22	20	42	47.5	Miscellaneous,	112	118	230	51.5
Cloves,	187	21	208	10.1	Molasses,	103	4	107	3.8
Coffee,	100	6	106	5.7	Mustard,	184	66	250	26.4
Condensed milk,	65	11	76	14.5	Nutmeg,	12	-	12	0.0
Confectionery,	24	-	24	0.0	Pepper,	333	43	376	11.4
Cream of tartar,	312	5	317	1.6	Syrups,	6	-	6	0.0
Flavoring extracts:					Tea,	28	-	28	0.0
Jamaica ginger,	4	1	5	20.0	Vinegar,	46	53	99	53.5
Lemon,	8	19	27	70.4					
Vanilla,	13	12	25	48.0	Total,	2,536	539	3,075	17.1

Drugs.

Eleven hundred and thirty-three samples of drugs were examined during the year, comprising for the most part the pharmacopœial preparations most liable to adulteration. The results are summarized in the table on

page 513. The drugs condemned as impure have failed in most cases to conform to the standards of the Pharmacopœia, or were found to be below the professed standard under which they were sold.

Comment has been made in past years on the wide deviation from the standards of such of the commoner pharmacopœial preparations as aqua



destillata, which, as a matter of fact, is rarely found pure. The distilled waters examined during the present year, for instance, were all found below the standard, in many cases containing higher residues than the tap water of the towns in which they were purchased.

Another significant fact to which notice has been called before is the high ratio of adulteration of such a cheap and abundant article as capsicum. Thirteen per cent. of the samples of cayenne purchased from drug stores were found to be adulterated, while the per cent. of adulteration of the cayenne purchased from the grocers was found to be but 1.6 per cent.

Glycerinum. — Only 5 per cent. of the glycerine samples examined during the year were found to contain arsenic, and no sample was found to be highly arsenical. When, in 1899, glycerine was first examined by this Board for arsenic, 68.9 per cent. of the samples were found arsenical, and some of them contained arsenic in dangerous quantities.

Various reputable manufacturers claimed at that time that it was impossible to produce a chemically pure glycerine, free from traces of arsenic, though they were willing and anxious to make every effort to accomplish this end. In view of the fact that nearly 95 per cent. of the glycerine samples examined last year contained no traces of arsenic, it will be seen that the problem could be readily solved. The chart on the preceding page shows very plainly the results of persistent efforts on the part of the Board in bringing about this result during five years. We have here a striking illustration of what can be accomplished by persistent and systematic notification, since this result has been achieved with but a single prosecution in the courts.

Oleum Limonis. — Thirty-three samples of lemon oil were collected and analyzed, 28 of which were impure. The index of refraction is one of the most important constants in determining the purity of lemon oil, especially when taken in connection with the polarization and specific gravity. The following table shows the refraction of pure lemon oil at temperatures varying from 20° to 40° C. : —

Refraction of Lemon Oil.

Temperature, C.	Index of Refraction.	Butyro-refractometer Reading.	Temperature, C.	Index of Refraction.	Butyro-refractometer Reading.
40.0	1.4655	59.4	30.0	1.4700	66.4
39.5	1.4657	59.7	29.5	1.4702	66.7
39.0	1.4659	60.0	29.0	1.4704	67.0
38.5	1.4662	60.4	28.5	1.4706	67.3
38.0	1.4464	60.8	28.0	1.4709	67.7
37.5	1.4666	61.1	27.5	1.4711	68.1
37.0	1.4668	61.4	27.0	1.4713	68.4
36.5	1.4671	61.8	26.5	1.4715	68.7
36.0	1.4673	62.2	26.0	1.4717	69.1
35.5	1.4675	62.5	25.5	1.4720	69.5
35.0	1.4677	62.8	25.0	1.4722	69.9
34.5	1.4679	63.1	24.5	1.4724	70.2
34.0	1.4682	63.4	24.0	1.4726	70.5
33.5	1.4684	63.7	23.5	1.4729	70.9
33.0	1.4686	64.2	23.0	1.4731	71.3
32.5	1.4688	64.5	22.5	1.4733	71.6
32.0	1.4691	64.9	22.0	1.4735	71.9
31.5	1.4693	65.3	21.5	1.4737	72.2
31.0	1.4695	65.6	21.0	1.4740	72.7
30.5	1.4697	65.9	20.5	1.4742	73.0
30.0	1.4700	66.4	20.0	1.4744	73.3

The Abbé refractometer has been added to the laboratory equipment during the year, for the purpose of examining essential oils.

Oleum Olivæ. — Forty-one samples of olive oil out of 137 examined were found impure. Most of these consisted wholly or in part of cottonseed oil. One sample contained 40 per cent. of sesame oil.

Phenacetine. — Seventy-five samples were examined, 13 of which contained large admixtures of acetanilid. Several successful prosecutions in court were instituted against wholesale dealers who were found to have supplied this part of the State with the spurious phenacetine in original packages.

Potassium Iodidum. — Two samples out of the 21 examined were found to consist of potassium bromide instead of potassium iodide. These were put out in original ten-pound packages by Lehn & Fink of New York.

Sodii Boras. — Seven samples were analyzed, 3 of which were found impure by reason of the usual large admixture of sodium bicarbonate. The Acme brand, the product of L. Beling & Co. of New York, was found to be thus adulterated. Another preparation put out by the same concern, under the name of "Bi-borax," purporting to be a mixture of borax and soda, was found to contain no borax.

Sodii Phosphas. — The comments made as to improvement in glycerine as regards the presence of arsenic apply also to sodium phosphate. In this case only about 5 per cent. of the samples examined were found to be arsenical. The worst sample of sodium phosphate examined in 1903 contained 2 parts of arsenic per 100,000. In 1902 the number of samples condemned as being arsenical amounted to 12 per cent. of the whole, while in 1901 32 per cent. were found arsenical.

Tinctura Iodi. — About 94 per cent. of the samples examined failed to conform to the requirements of the Pharmacopœia. Of the samples examined, 8 were above the strength, 9 were of the necessary strength required, while those below the standard were as follows: —

17	samples	were	between	90	and	95	per	cent.	of the	United	States	pharmacopœial	strength.
37	"	"	"	80	"	90	"	"	"	"	"	"	"
35	"	"	"	75	"	80	"	"	"	"	"	"	"
34	"	"	"	60	"	70	"	"	"	"	"	"	"
13	"	"	"	50	"	60	"	"	"	"	"	"	"
9	"	"	"	40	"	50	"	"	"	"	"	"	"
6	"	"	"	30	"	40	"	"	"	"	"	"	"
3	"	"	"	20	"	30	"	"	"	"	"	"	"

The standard fixed by the Pharmacopœia, viz., 70 grams of iodine in sufficient alcohol to make 1,000 cubic centimeters, is by no means a severe one. There is absolutely no reason why this preparation should be so commonly found wanting. It is a significant fact that 5 samples of the tincture examined during the year ranged from 113 to 164 per cent. of the strength required.

One sample of tincture of iodine (put up and sold by Harry A. Tobey), which was the subject of a complaint at court in Nantucket, was found to be made with wood alcohol.

Miscellaneous Drugs.

Fifty-four samples of drugs of a miscellaneous character were examined, 9 of which were pronounced impure. Patent medicines, in which alcohol or some other active principle was to be looked for, comprise the largest class of articles examined under this head.

Face Bleaches and Freckle Lotions. — The following preparations were analyzed and published during the year: Mme. Ruppert's Face Bleach, made by Mme. A. Ruppert, New York; Soule's Moth and Freckle Lotion, made by Mrs. C. A. Soule of Lynn; and Mrs. McCorrison's Diamond Lotion, all containing corrosive sublimate, without poison labels. Also Champlin's Liquid Pearl, made by the Champlin Manufacturing Company of New York, containing a lead salt, and without the poison label.

Gluten Flour. — Four samples were analyzed, one of which was found to contain 59.4 per cent. of starch.

Hair Restorer. — Mary T. Goldman's Hair Restorer, made in St. Paul, Minn., was found to be a solution of silver nitrate, and contained no poison label.

Opium Cure. — A preparation known as St. Anne's Morphine Cure was examined and found to contain 1 grain of morphine and 1.8 grains of caffein per fluid ounce. According to the directions, 2 teaspoonfuls of this preparation were to be taken four times a day.

Quinine Pills. — Most of the 2-grain quinine pills found in the market contain as a matter of fact very nearly 2 grains of hydrated quinine sulphate per pill. A few samples have been found to contain considerably less than this amount, and several had a quantity of magnesium silicate.

Summary of Drug Statistics.

	Genuine.	Adulterated.	Total.	Per Cent. of Adulteration.
Acidum tannicum,	2	1	3	33.3
Æther,	9	3	12	25.0
Alcohol,	9	5	14	35.7
Aqua ammoniæ,	13	6	19	31.6
Aqua destillata,	–	15	15	100.0
Bismuthi subnitras,	1	–	1	0.0
Capsicum,	87	13	100	13.0
Cera alba,	12	12	24	50.0
Cera flava,	25	40	65	61.5
Chloroformum,	3	6	9	33.3
Extractum glycyrrhizæ,	–	1	1	–

Summary of Drug Statistics — Concluded.

	Genuine.	Adulterated.	Total.	Per Cent. of Adulteration.
Extractum glycyrrhizæ fluid,	1	-	1	0.0
Ferri et quininæ citras,	14	1	15	6.6
Glycerinum,	106	6	112	5.3
Liquor calcis,	3	-	3	0.0
Magnesii sulphas,	7	-	7	0.0
Miscellaneous,	45	9	54	16.6
Oleum limonis,	5	28	33	84.8
Oleum olivæ,	96	41	137	29.8
Oleum ricinæ,	1	-	1	0.0
Opii pulvis,	11	3	14	21.4
Phenacetine,	62	13	75	17.3
Potassii bitartras,	6	-	6	0.0
Potassii iodidum,	19	2	21	9.5
Pulvis glycyrrhizæ compositus,	23	2	25	8.0
Quininæ sulphas,	7	-	7	0.0
Sodii boras,	4	3		42.9
Sodii phosphas,	18	1	19	5.3
Spiritus ætheris nitrosi,	-	11	11	100.0
Spiritus menthæ piperitæ,	-	1	1	-
Sulphur lotum,	24	21	45	46.6
Sulphur præcipitatum,	1	58	59	98.3
Sulphur sublimatum,	1	-	1	0.0
Syrupus,	4	2	6	33.3
Tinctura iodi,	11	165	176	93.8
Tinctura opii,	2	-	2	0.0
Tinctura opii camphorata,	4	-	4	0.0
Vinum rubrum,	-	1	1	-
Zingiber,	26	1	27	37.0
Total,	662	471	1,133	41.5

Summary of Food and Drug Statistics for the Year ending Sept. 30, 1903.

	Genuine.	Adulterated.	Total.	Per Cent. of Adulteration.
Milk,	3,814	1,979	5,793	34.2
Foods exclusive of milk,	2,536	539	3,075	17.1
Drugs,	662	471	1,133	41.5
Total,	7,012	2,979	10,001	29.8

Inspection of Liquors.

The samples of liquors submitted for analysis by the proper officers of cities and towns throughout the State, for the year ending Dec. 31, 1903, amounted to 210 in number. Most of the samples examined were of cider or beer, to determine whether or not they stood above 1 per cent. by volume in alcohol at 60° F.

From its content in alcohol, an analyst's findings regarding a certain sample of liquor may exonerate the dealer suspected of violating the liquor law, while yet, by the very reason of its being low in alcohol, the same sample would be placed in the adulterated list as regards non-conformance to a standard of purity.

As a result of the added liquor work, numerous cases during the year have called for the analyst's appearance in court. While in most cases the simple determination of alcohol has been all that was necessary, there are instances where additional work was required. For instance, in one case during a raid by officers on a Brockton drug store, one of the clerks in the store very quickly poured some sulpho-naphthol into the jug of liquor which was about to be seized. This substance was intended to disguise the character of the liquor, and added considerably to the work of determining the alcohol.

Another instance where an attempt was made to foil the officers occurred in the same city. In this case it was the custom of the proprietor of the store to keep all the whiskey dispensed to patrons in the water tank of an unused water-closet. By an ingenious contrivance the ballcock in the tank was so arranged that the inflow of water to the tank was ordinarily cut off. When, however, a raid was suspected, on a given signal to the attendant in charge, the tank could be emptied and flushed with water by pulling the chain, and the whiskey allowed to quickly flow down through the sewer. In both the above cases, the character of the samples submitted for analysis was such as to convict the offender.

Arsenic in Wall Paper, Fabric, etc.

For the year ending Dec. 31, 1903, 17 samples of wall paper and cloth were examined for arsenic, 4 of which were found to contain it in excess of the standard fixed by law. The worst sample contained .14 grain of arsenic per square yard.

Respectfully submitted,

ALBERT E. LEACH,
Analyst.

THE DETERMINATION OF COMMERCIAL GLUCOSE IN SOME SACCHARINE PRODUCTS.

By ALBERT E. LEACH, *Analyst of the Board.*

The determination of commercial glucose in such products as molasses and maple syrup, wherein the amount of invert sugar is comparatively small, is readily accomplished by some such method as that given in the annual report for 1900, page 658,* but its determination in such products as honey, jams and jellies presents some obstacles.

At first sight it would seem to be only necessary to divide the invert polarization of the sample at 87° C. by the assumed factor for the polarization of commercial glucose to obtain the percentage of the latter. As a matter of fact, a normal solution of commercial glucose polarizes somewhat lower after than before inversion, and the reading at 87° is very much lower than that at 20° C. The difference between the readings at the high and low temperature may be due in part to expansion, but another disturbing influence enters in to affect the results, namely, the action of the acid used in inversion on the maltose and the dextrin of the glucose at high temperatures. If a normal solution of commercial glucose be subjected to inversion in the ordinary manner, it will be found impossible to obtain a constant reading at a temperature of 87° C. The polarizing figure drops quite rapidly, due no doubt to the hydrolyzing action of the hydrochloric acid on the maltose and the dextrin. On this account it becomes necessary, when analyzing samples of honey, jams and jellies containing commercial glucose, to neutralize the sample as soon as possible after inversion, before the hydrolytic action of the acid has set in to any appreciable extent.

It is found best to prepare separate normal solutions of the sample, on one of which the direct polarization is obtained in the usual manner. For the invert readings the second solution is prepared as follows: weigh out half the normal weight of the sample, 13.024 grams, in a 100 cubic centimeter graduated flask. Dissolve in about 70 cubic centimeters of water, and add 7 cubic centimeters of concentrated hydrochloric acid. Then heat to 68° C. and cool in the usual manner for inversion. Add a few drops of

* Food and drug reprint, page 42.

phenol-phthalein, and enough sodium hydroxide to neutralize. Discharge the pink color with a few drops of dilute hydrochloric acid, cool again, add from 5 to 10 cubic centimeters of the appropriate clarifier, which in the case of honey would be alumina cream, and make up to the mark. Constant and presumably correct readings may be made with this solution both at room temperature and at 87° C., using the 200 millimeter tube and multiplying the readings by two.

Following are the results of a series of readings made on five samples of commercial glucose by H. C. Lythgoe, showing the relation between the two invert readings at 22° and 87° respectively, as well as the ratio of the invert polarization at 87° to the direct polarization. The readings were made on solutions subjected to the above method of inversion and neutralization.

Density.	Source.	Polarization.			Ratio of C. to B.	Ratio of C. to A.
		A. Direct.	B. Invert at 22° C.	C. Invert at 87° C.		
42° Bé.,	Boston Molasses Company, No. 1, . .	156.6	153.4	146.6	0.956	0.936
42° Bé.,	Boston Molasses Company, No. 2, . .	158.6	154.6	149.0	0.964	0.940
42° Bé.,	Illinois Sugar Refining Company, . .	169.6	165.4	159.4	0.964	0.940
43° Bé.,	New England Confectionery Company, .	167.4	162.8	155.0	0.952	0.926
45° Bé.,	Illinois Sugar Refining Company, . .	174.0	171.0	161.2	0.943	0.927
	Average, ...	. .	. .	. .	0.956	0.933

Obviously, then, if we are to express results in terms of commercial glucose polarizing at an assumed figure (for example, 175, as in the provisional method), it will be necessary in the case of jellies and jams to divide the high reading at 87° C. after inversion by 93 per cent. of the assumed factor, or if 175 is the factor, by 163. It is obvious also that the calculation of invert sugar in products which contain also considerable commercial glucose is a difficult one, by reason of the influence of the commercial glucose on the polarization. We are at present working on this problem and hope before long to be able to work out a reliable formula for the calculation of invert sugar in the presence of commercial glucose.

It has been thought best, however, at this stage to call attention to these peculiarities of commercial glucose, in view of the fact that it is understood that the method described in the 1900 report, page 658, while well adapted for molasses and syrups, is being quite largely used for jams and jellies as well. There is no doubt that a rough approximation can be gained by the use of the unmodified method for all these products, but where verification of manufacturers' formulas is involved, or where more exact methods are needed, the above precautions should be borne in mind.

Composition and Adulteration of Ground Mustard.

By Albert E. Leach, *Analyst of the Board.*

Mustard has long taken the lead as the most extensively adulterated of all the spices, especially in localities where no system of food inspection prevails. The custom of deliberately mixing cereal flour or starch with ground mustard was practised for many years, and in fact continued long after the serious adulteration of other spices had been held in check by the increased enforcement of pure food laws.

Coloring with turmeric was also a time-honored custom, and in fact still prevails, except in localities where the public have been educated to view with suspicion the deep yellow color of the product. Of late the employment of other colors than turmeric, such, for example, as various of the oil-soluble coal tar dyes, has arisen to claim the attention of the analyst.

All the above forms of gross sophistication can without doubt be dealt with by almost any food commission or health board having in charge the enforcement of pure food laws, acting under the general food laws of their State, and without the fixing of definite standards. It is, however, in connection with other and perhaps milder forms of adulteration of mustard that the necessity of carefully fixed standards are of greater importance. The questions of how much starch, if any, should be allowed in ground mustard due to weed seeds, and whether mustard hulls have been mixed with the mustard " flour" in excess of the amount found in the whole seed, should be largely settled by appropriate standards, if possible.

Commercial mustard " flour," unlike the other spices, is not ground from the whole seed, but is a manufactured product, being deprived as a rule of a large portion of the fixed oil, and most of the hulls, so as to insure a fine, even powder. Hence, in fixing standards for what the trade understands as mustard flour, difficulties are met with not encountered in the ground whole spices.

Very complete analyses of nearly all the spices excepting mustard and turmeric have been made by Winten, Ogden and Mitchell,* and the same analysts have made partial analyses of commercial mustard flours found on sale in Connecticut.†

* Twenty-second Annual Report of the Connecticut Experiment Station (1898), p. 184. † *Ibid*, p. 169.

The following table shows the results of analyses made in the writer's laboratory of a number of the commoner varieties of mustard, both yellow and brown. The mustard "flours" were prepared in the same manner as the commercial article, from seed separated as completely as possible from the hulls, and having the usual proportion of fixed oil removed by pressure. The "hulls" analyzed were some that had been separated from the seed in the ordinary process of sieving, in the manufacture of the flour, and afterwards reduced by grinding to a fine powder. The six varieties of whole seed examined were each ground directly in a porcelain power mill of the type known as a "chaser," yielding in each case a fine, oily mass, hardly suited for a commercial product, but very useful in serving as a basis for standards, as showing all the components of the seed in their natural proportions. Much of the analytical work serving as a basis for this table of analyses was done by Mr. Arthur D. Smith.

	Moisture (Per Cent.).	Total Ash (Per Cent.).	Water-soluble Ash (Per Cent.).	Ash Insoluble in HCl. (Per Cent.).	Total Ether Extract (Per Cent.).	Volatile Ether Extract (Per Cent.).	Non-volatile Ether Extract (Per Cent.).	Alcohol Extract (Per Cent.).	Total Nitrogen (Per Cent.).	Volatile Oil (Per Cent.).	Crude Fiber (Per Cent.).	Reducing Matters by Acid Conversion, as Dextrose (Per Cent.).	Reducing Matters by Diastase, as Dextrose (Per Cent.).	On Dry Fat-free Substance.					
														Alcohol Extract (Per Cent.).	Total Nitrogen (Per Cent.).	Total Ash (Per Cent.).	Crude Fiber (Per Cent.).	Reducing Matters by Acid Conversion (Per Cent.).	Reducing Matters by Diastase (Per Cent.).
Mustard "flour" as prepared commercially: *—																			
English brown,	5.55	5.58	0.27	.08	17.46	0.0	17.46	25.31	6.37	3.98	3.28	11.89	0.71	32.88	8.27	7.25	4.26	15.43	0.93
California brown,	7.23	4.90	0.23	.13	20.64	0.0	20.64	19.22	6.75	4.67	2.27	4.87	0.23	26.64	9.36	6.79	3.15	6.75	0.32
German brown,	9.50	5.25	0.09	.50	16.28	0.0	16.28	21.98	7.13	3.09	2.45	5.63	0.22	29.61	9.61	7.07	3.30	7.59	0.30
Average of brown flours,	7.43	5.24	0.19	.24	18.19	0.0	18.19	22.17	6.75	3.91	2.67	7.47	0.39	29.71	9.08	7.04	3.57	9.92	0.56
German yellow,	7.47	4.73	0.18	.35	12.65	0.0	12.65	24.21	7.44	-	1.87	6.12	0.23	29.93	9.20	5.85	2.31	7.57	0.28
California yellow,	5.09	4.69	0.22	.29	25.95	0.0	25.95	20.78	6.21	-	2.21	5.75	0.00	30.13	9.00	6.81	3.20	8.34	0.00
Average of yellow flours,	6.28	4.66	0.20	.32	19.30	0.0	19.30	22.49	6.83	-	2.04	5.94	0.12	30.03	9.10	6.33	2.75	7.95	0.14
Average of all varieties of flour,	6.96	5.03	0.19	.27	18.59	0.0	18.59	22.30	6.78	-	2.42	6.85	0.28	29.84	9.09	6.75	3.30	9.13	0.37
Mustard hulls as removed in preparation of flour: †—																			
English brown,	6.83	5.03	0.95	.14	13.81	0.0	13.81	14.21	3.89	2.26	10.90	9.90	1.20	17.89	4.83	6.34	13.74	12.52	1.51
No. 2 brown,	8.67	4.43	1.26	.23	10.51	0.0	10.51	14.15	4.04	1.83	11.34	14.05	3.56	17.52	5.00	5.48	14.28	17.38	4.40
Average of brown hulls,	7.75	4.73	1.11	.19	12.16	0.0	12.16	14.18	3.97	2.05	11.12	11.98	2.38	17.70	4.92	5.91	14.01	14.95	2.95
No 1 yellow,	6.46	4.56	2.33	.05	7.03	0.0	7.03	11.07	3.03	-	16.46	20.40	6.11	12.79	3.58	5.15	19.02	23.58	7.06
No. 2 yellow,	5.36	4.65	1.91	.22	6.63	0.0	6.63	10.46	3.22	-	17 69	20.00	4.21	11.89	3.66	5.28	20.10	22.73	4.77
California yellow,	9.12	4.59	1.78	.05	7.79	0.0	7.79	8.51	3.60	-	16.08	19.90	3.74	10.31	4.34	5.52	19.34	23.95	4.49
German yellow,	8.46	4.66	1.80	.04	6.17	0.0	6.17	8.07	2.90	-	18.95	17.35	2.91	9.45	3.40	5.46	22.20	20.30	3.40
Average of yellow hulls,	7.35	4.65	1.95	.09	6.90	0.0	6.90	9.53	3.19	-	17.29	19.41	4.24	11.11	3.74	5.35	20.16	22.64	4.93
Average of all samples of hulls,	7.48	4.65	1.67	.12	8.66	0.0	8.66	11.07	3.45	-	15.20	16.96	3.62	13.31	4.14	5.56	18.11	20.23	4.27
Whole ground mustard seeds: ‡—																			
Bari brown,	5.88	4.07	0.46	.22	37.81	0.0	37.81	13.70	4.10	2.76	4.41	7.34	1.76	24.33	7.28	7.23	7.83	13.03	3.13
California brown,	6.49	3.84	0.45	.21	35.39	0.0	35.39	14.26	4.49	2.91	4.21	6.94	1.78	24.54	7.73	6.61	7.24	11.94	3.06
Average of brown seeds,	6.18	3.95	0.45	.21	36.60	0.0	36.60	13.98	4.29	2.83	4.30	7.14	1.77	24.43	7.50	6.92	7.53	12.48	3.09
German yellow,	6.69	4.34	0.63	.56	27.19	0.0	27.19	17.75	5.09	0.0	4.87	9.35	1.45	26.85	7.70	6.61	7.36	14.44	2.19
Dutch yellow,	5.93	4.83	0.73	.33	30.84	0.0	30.84	14.98	4.12	0.0	6.53	10.06	1.82	23.69	6.51	7.64	10.33	15.91	2.87
English yellow,	6.43	4.37	9.52	.16	27.45	0.0	27.45	16.31	3.96	0.0	4.95	8.42	0.92	24.62	6.00	6.61	7.34	12.74	1.39
California yellow,	6.82	4.05	0.57	.42	28.64	0.0	28.64	16.11	4.72	0.0	5.28	9.60	1.15	24.96	7.31	6.28	8.18	14.88	1.78
Average of yellow seeds,	6.47	4.39	0.61	.37	28.53	-	28.53	16.29	4.47	-	5.41	9.36	1.33	25.03	6.88	6.78	8.30	14.49	2.05
Average of all six samples of seeds,	6.37	4.25	0.56	.32	31.22	-	31.22	15.50	4.41	-	5.04	8.62	1.48	24.83	7.09	6.83	8.05	13.82	2.40

* Freed from hulls and with a portion of the fixed oil removed.

† These hulls necessarily have a little of the inner seed adhering thereto.

‡ Ground to a fine paste with full content of oil and hulls.

Method of Analysis. — The methods of analysis employed were in the main those adopted provisionally by the Association of Official Agricultural Chemists.*

In the case of the brown seed, the developed volatile oil was determined by the following method: —

Determination of Mustard Oil in Mustard Flour. — *Roeser's Method.* — Mix 5 grams of the sample with 60 cubic centimeters of water and 15 cubic centimeters of 60 per cent. alcohol, and let stand for two hours. Distil into a flask containing 10 cubic centimeters of ammonia, and after about two-thirds of the solution have been distilled off, mix the ammoniacal distillate with 10 cubic centimeters of tenth-normal silver nitrate solution, and allow the mixture to stand for twenty-four hours, after which make up with water to 100 cubic centimeters. Filter, and treat 50 cubic centimeters of the filtrate with 5 cubic centimeters of tenth-normal potassium cyanide solution. Titrate the excess of cyanide with the tenth-normal silver nitrate, using as an indicator a 5 per cent. solution of potassium iodide made slightly ammoniacal.

The percentage of mustard oil present is found by multiplying by 2 the number of cubic centimeters of silver nitrate solution taken up by the oil, and multiplying this product by the factor 0.3137.

Starch in Mustard. — Pure mustard contains absolutely no starch, yet mustard hulls of all varieties by the diastase method show considerable copper-reducing matter, which is not due to starch, and should not be attributed to it.

One sample of mustard hulls showed 7 per cent. of reducing matter, reckoned as dextrose in the moisture-and-fat-free substance.

The material of the seed itself is comparatively free from such reducing matter, and when the separation from the hulls is complete, should show hardly a trace of reducing material by the diastase treatment. The mustard flours of the above table were practically free from contaminating starch, as shown by the microscope, the small amount of reducing action under the diastase treatment being undoubtedly due to the traces of hulls which were left in them.

Hence it is often of considerable importance to ascertain whether the reducing matter is due to starch or to hulls, and this can readily be accomplished by a microscopical examination, which furnishes the very best, if not the only means of judging the character and extent of starch contamination, when the amount of starch is small.

In the standards recently adopted by the Secretary of Agriculture for certain food products † standard ground mustard is defined as "containing not more than 2.5 per cent. of starch by the diastase method." It would seem as if some modification of this standard should be made.

* United States Department of Agriculture, Bureau of Chemistry, Bulletin 65, part X., "Spices"

† Office of the Secretary of Agriculture, Circular No. 10, p. 11.

From the fact that among the samples recorded in the table on page 520, 1.82 per cent. is the maximum of reducing material reckoned as dextrose found in the air-dry substance for mustard *ground from the entire seed*, and found by the microscope to contain only the minutest traces of contaminating weed starch, it would seem as if 2.5 per cent. of reducing matter were excessive.

Any actual starch present in ground mustard is due either to fraudulent admixture or to the presence of starch-containing weed seeds, common in some of the cheaper varieties of mustard seed. If contamination with foreign seed were to be legalized to the extent of 2½ per cent. of actual starch, this would mean a percentage of foreign material far in excess of that figure, since starch is but one ingredient of these foreign seeds.

In view of the fact that starch is foreign to pure mustard, and that copper-reducing materials other than starch exist in mustard hulls under the diastase treatment, it would seem as if the standard should rule out more than mere traces of starch as shown by the microscope. Furthermore, since the removal of the fat in more or less degree is customary, it would be better to express constants on the moisture-and-fat-free basis, limiting the reducing matter by the diastase method in the moisture-and-fat-free substance to say 2.5 per cent., not of actual starch according to the present wording of the standard, but to "reducing matter reckoned in terms of dextrose," or, if desired, the equivalent "in terms of starch."

Typical of the cheap varieties of mustard high in foreign weed seed, which it is claimed by manufacturers cannot be removed from the mustard by sieving or by winnowing, are the Dakota mustard and some of the lower grade German seeds. By reason of the cheapness of these seeds there is constant temptation to use them. Such varieties were for various reasons not included in the above table, though the varieties analyzed were intended to cover a tolerably wide range. It is in fact questionable whether seed so highly contaminated with foreign material as the Dakota mustard should be allowed at all.

Following is the analysis of a sample of Dakota mustard flour, found by the microscope to be free from more than traces of hull tissue. It was found to contain over 3 per cent. of actual starch in the water-and-fat-free substance, since, in the absence of hulls, practically all the reducing matter under the diastase treatment was due to starch.

Dakota Mustard Flour.

	Air-dry Powder (Per Cent.).	Moisture-and-Fat-free Substance (Per Cent.).
Moisture,	7.42	-
Total ash,	7.80	9.71
Water-soluble ash,	0.46	0.57
Ash insoluble in HCl,	0.75	0.93
Ether extract,	12.23	-
Alcohol extract,	23.81	29.64
Total nitrogen,	6.81	8.51
Volatile oil,	3.76	4.68
Crude fiber,	2.28	2.84
Reducing matter, by acid conversion, as dextrose,	14.05	17.48
Reducing matter, by diastase, as dextrose,	2.87	3.57
Reducing matter, by diastase, as starch,	2.58	3.21

Numerous varieties of starch-containing weed seed were found in the whole Dakota mustard seed from which the above flour was prepared. Three of the most common varieties were picked out and analyzed for starch. One of these, evidently an inferior grade of broken wheat, was found to contain 70.93 per cent. of starch; another, a small circular seed, contained 70.65 per cent.; and a third, a small angular seed, contained 67.5 per cent. of starch, all three starch determinations being made by the diastase treatment.

Added Mustard Hulls. — Another method of producing a cheap mustard flour consists in the addition of ground mustard hulls. While it is true that the higher grades of mustard flour are deprived almost entirely of hulls, some are occasionally found that contain added hulls to an extent exceeding the amount of hulls in the whole seed. This practice should obviously be considered as a form of adulteration. Such an excess of hulls is rendered obvious by a microscopical examination, and may be confirmed by a chemical analysis. For this purpose certain additional standards would be helpful.

The main points of difference between hulls and seed substance of pure mustard are indicated chemically by such constants as the total nitrogen, the crude fiber and the reducing matter by diastase. The following table shows this in summarized form: —

In the Water-and-Fat-free Substance.

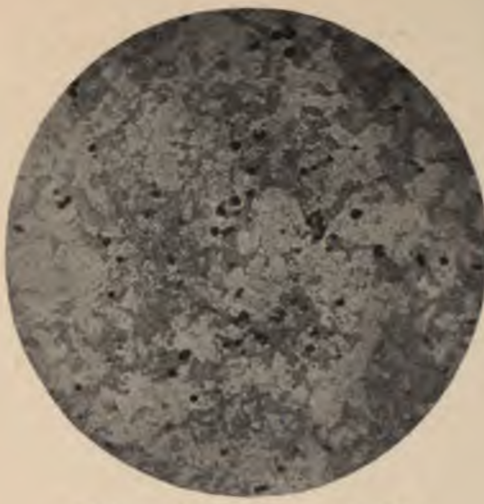
		Mustard Flour (Per Cent.).	Mustard Hulls (Per Cent.).	Whole Seed (Per Cent.).
Total nitrogen,	Maximum,	9.61	5.00	7.73
	Minimum,	8.27	3.40	6.00
	Mean,	9.09	4.14	7.09
Crude fiber,	Maximum,	4.26	22.20	10.33
	Minimum,	2.31	13.74	7.24
	Mean,	3.24	18.11	8.05
Reducing matter as dextrose, by diastase,	Maximum,	0.93	7.06	3.13
	Minimum,	0.00	1.51	1.39
	Mean,	0.37	4.27	2.40

One sample of commercial mustard flour comparatively free from starch, but condemned by the writer on account of added hulls as shown unmistakably by the microscope, exhibited the following constants in the water-and-fat-free substance: —

	Per Cent.
Total nitrogen,	6.97
Crude fiber,	7.69
Reducing matter as dextrose, by diastase,	2.20

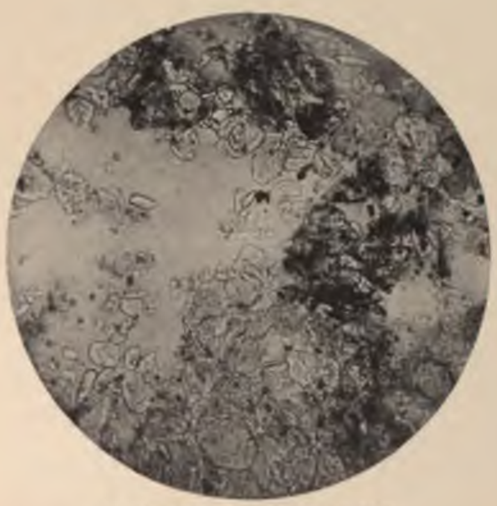
In this sample the microscope plainly showed the fragments of hull to form the chief feature of the mass, largely exceeding the material of the seed tissue.

Suggested Standards. — Based on the above analyses, the following standards are suggested for ground mustard, expressed on the moisture-and-fat-free substance: reducing material by diastase treatment should not exceed 2.5 per cent. expressed as dextrose; crude fiber should not exceed 5 per cent.; and total nitrogen should be not less than 8 per cent. As shown by the microscope the sample should be free from more than minute traces of starch, and should not exhibit an excess of hulls over seed tissue.



Dakota Mustard Flour, X 110.

Dark spots show starch grains of foreign weed seed, stained with iodine.



Powdered Turmeric, X 110.

Showing starch grains, fragments of cell tissue, coloring matter, etc.

THE COMPOSITION OF TURMERIC.

By ALBERT E. LEACH, *Analyst of the Board.*

Turmeric, while largely used as an adulterant of other spices (especially ginger and mustard), possesses some value as a condiment in itself, forming for instance the chief ingredient of curry powder. Turmeric (*Curcuma longa*) belongs to the same family (*Zingiberacœ*) as ginger, having a perennial rootstock and an annual stem. It is a native of the East Indies and Cochin-China. Its chief ingredients are starch, a volatile oil, a yellow coloring matter (curcumin), cellulose and gum.

Curcumin ($C_{14}H_{14}O_4$) is insoluble in cold water, but readily soluble in alcohol. It is extracted from powdered turmeric by boiling the latter with water, filtering, and extracting the residue with boiling alcohol. The alcoholic solution is filtered, evaporated, and the residue extracted with ether. The ether extract contains the curcumin, together with a small amount of volatile oil.

Curcuma oil is an orange-yellow, slightly fluorescent liquid, its specific gravity being 0.942.

The following analyses of turmeric were made in this laboratory: —

VARIETY.	Moisture (Per Cent.).	Total Ash (Per Cent.).	Ash Soluble in Water (Per Cent.).	Ash Insoluble in HCl. (Per Cent.).	Total Nitrogen (Per Cent.).	Protein N x 6.25 (Per Cent.).	Total Ether Extract (Per Cent.).	Volatile Ether Extract (Per Cent.).	Non-volatile Ether Extract (Per Cent.).	Alcohol Extract (Per Cent.).	Crude Fiber (Per Cent.).	Reducing Matter by Acid Conversion, as Starch (Per Cent.).	Starch by Diastase Method (Per Cent.).
China, . .	9.03	6.72	5.20	.11	1.73	10.81	10.86	2.01	8.84	9.22	4.45	48.69	40.05
Pubna, . .	9.08	8.52	6.14	-	0.97	6.06	12.01	4.42	7.60	7.28	5.84	50.08	29.56
Alleppi, . .	8.07	5.99	4.74	-	1.56	9.75	10.66	3.16	7.51	4.37	5.83	50.44	33.03
Average, .	8.73	7.07	5.36	-	1.42	8.88	11.17	3.19	7.98	6.96	5.37	49.73	34.21

Turmeric as an Adulterant. — Turmeric is a material especially adapted by its deep-yellow color to intensify mustard and ginger, especially when these spices are adulterated with the lighter-colored cereal starches, hence

it is very commonly found in these spices, both with and without other adulterants.

It is frequently used in small quantities in adulterated cayenne, mace and various spices, to counteract the colors of other dyestuffs, such as ground redwood, which in itself would be too intense if used alone. Turmeric when present to any marked extent in a powdered spice may be detected chemically by extracting the material with alcohol, pouring off the latter and soaking in it a piece of filter paper. Turmeric, if present, will stain the latter yellow, turning red with alkali, especially apparent after drying. Soak the yellow paper in a solution of borax, acidulated slightly with hydrochloric acid. When dry, a rose-red color will indicate turmeric, turning dark olive when dilute alkali is applied.

REPORT

UPON THE

PRODUCTION, DISTRIBUTION AND USE OF DIPHTHERIA ANTITOXIN,

AND UPON BACTERIOLOGICAL DIAGNOSIS,

FOR THE

YEAR ENDED MARCH 31, 1904.

REPORT

UPON THE

PRODUCTION, DISTRIBUTION AND USE OF DIPHTHERIA ANTITOXIN

FOR THE

YEAR ENDED MARCH 31, 1904.

Under the provisions of chapter 480 of the Acts of 1903, the State Board of Health was authorized to "produce and distribute antitoxin and vaccine lymph for the use of the people of the Commonwealth."

The Board had already, under its general powers authorizing it to "take cognizance of the interests of health and life among the citizens of the Commonwealth," undertaken the work of producing and distributing antitoxin since 1895, with entire success and much to the satisfaction of all who are in any way concerned in its use. The product which was made was kept up to a high standard of strength, the supply was always equal to the demand, and physicians using it reported a uniform degree of success in its use.

Under the authority of the act of 1903 a new laboratory has been built and equipped with suitable apparatus and furnishings, and before the present report is published will be prepared to furnish both antitoxin and vaccine lymph to boards of health throughout the State.

The following report relates to the production and distribution of antitoxin and the results of its use during the year ended March 31, 1904, this period having been selected since the work of distribution began in April, 1895, although the preparatory work was begun in the previous year. The use of antitoxin is approximately an index of the prevalence of diphtheria.

In the annual reports of 1901 and 1902 a statement was presented of the work of the previous years, with an approximate estimate of the saving of life effected by the general introduction of the use of antitoxin throughout the State. The returns of 1,834 additional cases, reported during the past year, only confirm and add cumulative testimony to the foregoing reports. Of these there were 175 deaths, or 9.5 per cent. Of the whole number of cases, however, only 1,390 were determined by examination to be positive cases of diphtheria, and of these there were 113 deaths, or 8.1 per cent.

In the table which was published in the report of 1901, and is herewith reproduced with the additional figures for 1902 and 1903, it was shown that while the diphtheria death-rate in the first half of the period had risen to more than 10 per 10,000 of the population nine times in twenty-one years, in the last half of the period it has risen only once above 10 per 10,000, and then only to 10.2. The death-rate from diphtheria, had antitoxin not been used in the past nine years, according to a careful calculation published in the report of 1901, would have risen to 10.6, 12.4, 11.0, 14.7 and 10.9 in the years 1895, 1896, 1897, 1900 and 1901.

As a condition of the use of antitoxin by boards of health, physicians, hospitals and others it was required that a return should be made in each case where antitoxin was used, upon blank forms furnished by the Board, upon which the details of each case were to be recorded. The Board is not merely a producer and distributer of antitoxin, but, under the provisions of the statutes, is authorized to "make sanitary investigations and inquiries in respect to the causes of disease, and especially of epidemics, and the sources of mortality." So far, therefore, as the relation of antitoxin to the saving of life from diphtheria is concerned, the Board cannot carry out the provisions of this law unless it is aided by the hearty co-operation of the physicians who use the product prepared by the Board, and are, therefore, the best judges as to its efficiency. By far the larger number of returns received is furnished by the different hospitals now existing in the larger cities, established for the reception of persons suffering with infectious diseases. If practising physicians were as careful as most of the hospital authorities to render an account of the antitoxin which is furnished to them, this report would be much more complete than it is now practicable to make it.

The supervision of antitoxin production has been carried on, as in former years, under the charge of Dr. Theobald Smith, at the Bussey Institute, near the Forest Hills station of the New York, New Haven & Hartford Railroad in Roxbury. The distribution has been conducted at the State House, from the office of the Board.

The strength of the serum employed has varied from 300 to 450 units per cubic centimeter, and the serum has usually been issued in a 5 cubic centimeter vial, containing 1,500 units. For convenience, a vial containing 20 cubic centimeters has also been employed for use where several patients are to be treated at once, or where unusually large doses are used. The serum has been distributed throughout the whole State, wherever it has been called for, to local boards of health, to contagious disease hospitals and to physicians in private practice, the latter being usually supplied through the local boards of health. In many instances the local board of health has placed it in charge of a druggist, where it could be obtained at any time during the day or night.

The total number of packages issued by the Board during the nine years ending with March 31, 1904, was as follows: —

In 1895–1896 (year ending March 31),	1,724 bottles.
In 1896–1897 (year ending March 31),	3,219 bottles.
In 1897–1898 (year ending March 31),	4,668 bottles.
In 1898–1899 (year ending March 31),	12,491 bottles.
In 1899–1900 (year ending March 31),	31,997 bottles.*
In 1900–1901 (year ending March 31),	53,389 bottles.*
In 1901–1902 (year ending March 31),	40,211 bottles.*
In 1902–1903 (year ending March 31),	33,475 bottles.*
In 1903–1904 (year ending March 31),	41,133 bottles.*
	222,307 bottles.

The mean annual death-rate from diphtheria during the past ten years, 1894–1903, during the greater portion of which antitoxin was in use throughout the State, was only 4.7 per 10,000 living, and there are not ten other successive years in the whole period of forty-three years, 1861–1903, in which the death-rate from this disease was so low.

The reported cases of diphtheria in the State in the past five years (not deaths) were as follows: —

1899,	7,134	1902,	7,036
1900,	12,641	1903,	6,888
1901,	9,793		

The total number of deaths from this cause in 1903 was 869, which is the least number in any year except one since 1874.

Death-rate from Diphtheria in Massachusetts, Forty-three Years (1861–1903).

Years.	Death-rate from Diphtheria per 10,000 Population.	Years.	Death-rate from Diphtheria per 10,000 Population.	Years.	Death-rate from Diphtheria per 10,000 Population.	Years.	Death-rate from Diphtheria per 10,000 Population.	Estimated Death-rate without use of Antitoxin.
1861,	8.9	1872,	4.9	1883,	8.6	1894,	7.4	-
1862,	9.2	1873,	4.7	1884,	8.6	1895,	7.1	10.6
1863,	18.2	1874,	5.7	1885,	7.8	1896,	6.6	12.4
1864,	15.9	1875,	11.4	1886,	7.8	1897,	5.5	11.0
1865,	9.8	1876,	19.6	1887,	7.9	1898,	2.6	5.6
1866,	6.4	1877,	18.7	1888,	8.7	1899,	8.7	9.0
1867,	4.5	1878,	14.6	1889,	10.2	1900,	5.3	14.7
1868,	5.7	1879,	18.1	1890,	7.8	1901,	4.1	10.9
1869,	5.4	1880,	13.4	1891,	5.3	1902,	3.0	7.4
1870,	4.6	1881,	18.1	1892,	6.2	1903,	2.8	7.4
1871,	5.0	1882,	9.6	1893,	5.8	-	-	-

* These numbers have reference to the actual number of bottles issued in packages of about 1,500 units each. In order to make this comparable with the figures of the first three years (1895-1898), a package of 1,000 units should be employed as a standard, so that the 200,205 bottles distributed during the last five years would be equivalent to about 300,000 of the strength at first employed.

An account was kept during the year of the amount of antitoxin employed in each case, with few exceptions, the result of which is shown in the following table: —

Amount of Antitoxin Used.	Number of Cases.	Deaths.	Amount of Antitoxin Used.	Number of Cases.	Deaths.
Less than 1,000 units, . .	16	2	4,000 to 5,000 units, . .	586	23
1,000 to 1,500 units, . .	28	3	5,000 to 10,000 units, . .	361	39
1,500 to 2,000 units, . .	150	9	10,000 to 15,000 units, . .	144	21
2,000 to 3,000 units, . .	109	6	15,000 to 20,000 units, . .	96	19
3,000 to 4,000 units, . .	201	16	20,000 and more units, . .	128	35

There were 1,090 reported cases in which the amount of antitoxin administered did not exceed 5,000 units in each case, and there were 729 reported cases in which the dose exceeded 5,000 units. Of these latter there were 368 in which the dose exceeded 10,000 units, and 128 in which it exceeded 20,000.

The whole number of cities and towns to which antitoxin was distributed during the year was 178, or 23 more than those which were published in the report of 1903. Among these are included at least 17 public and private hospitals and other establishments to which distribution was made, the quantity used in these institutions being about one-half of the whole product distributed during the year. The actual number of cities and towns in each year was probably somewhat larger than these figures, since a few of the more distant cities acted as distributing centres for small towns in their neighborhood, and in some instances no returns were made from these towns. This serum was distributed to local boards of health and to physicians in the following cities and towns: —

Number of Bottles of Diphtheria Antitoxin distributed from April 1, 1903, to March 31, 1904.

City or Town.	Number of Bottles.	City or Town.	Number of Bottles.
Acton, ...	18	Attleborough, ...	42
Adams, ...	60	Avon, ...	18
Agawam, ...	24	Ayer, ...	15
Amesbury, ...	34	Barnstable, ...	9
Andover, ...	30	Becket, ...	18
Arlington, ...	254	Bedford, ...	6
Ashland, ...	4	Belchertown, ...	18
Athol, ...	6	Belmont, ...	28

Number of Bottles of Diphtheria Antitoxin distributed from April 1, 1903, to March 31, 1904 — Continued.

City or Town.	Number of Bottles.	City or Town.	Number of Bottles.
Bernardston,	6	Dighton,	24
Beverly,	60	Dudley,	6
Billerica,	6	Duxbury,	6
Boston:		East Bridgewater,	18
Children's Hospital,	1,250	East Longmeadow,	6
City Hospital,	10,126	Easton,	50
Deer Island Hospital,	12	Edgartown,	6
General supply,	5,798	Everett,	78
Long Island Hospital,	6	Fall River,	599
Massachusetts Charitable Eye and Ear Infirmary.	60	Fitchburg,	73
Massachusetts General Hospital,	50	Foxborough,	36
Massachusetts Homœopathic Hospital,	45	Framingham,	60
Parental School,	12	Franklin,	9
St. Mary's Infant Asylum,	295	Gardner,	18
Schoolship "Enterprise,"	12	Georgetown,	22
West End Nursery,	126	Gloucester,	1,444
Bourne,	6	Groton,	6
Boxborough,	6	Hanover,	12
Blackstone,	6	Hardwick,	6
Braintree,	54	Haverhill,	182
Bridgewater,	6	Holbrook,	36
Brockton,	320	Holliston,	12
Brookfield,	12	Holyoke,	211
Brookline,	430	Hopedale,	42
Cambridge,	2,278	Hopkinton,	6
Hospital,	250	Hudson,	36
Canton,	90	Hull,	4
Chelsea,	187	Hyannis,	6
Cheshire,	12	Hyde Park,	96
Chicopee,	72	Ipswich,	6
Clinton,	48	Jefferson,	6
Cohasset,	30	Kingston,	6
Colrain,	2	Lancaster,	6
Concord,	30	Lawrence,	1,125
Cottage City,	6	Lenox,	12
Danvers,	48	Leominster,	36
Dedham,	45	Lexington,	18

Number of Bottles of Diphtheria Antitoxin distributed from April 1, 1903, to March 31, 1904—Continued.

City or Town.	Number of Bottles.	City or Town.	Number of Bottles.
Littleton,	8	Orleans,	4
Lowell,	1,050	Palmer,	34
Ludlow,	6	Peabody,	96
Lynn,	1,667	Pittsfield,	200
Malden,	376	Plymouth,	36
Mansfield,	9	Provincetown,	66
Marblehead,	176	Quincy,	344
Marlborough,	316	Randolph,	26
Marshfield,	54	Reading,	83
Maynard,	39	Revere,	85
Medfield,	12	Rockland,	78
Medford,	151	Rockport,	332
Medway,	24	Salem,	949
Melrose,	168	Salisbury,	6
Merrimac,	31	Saugus,	30
Methuen,	36	Scituate,	15
Middleborough,	6	Sharon,	24
Milford,	252	Shelburne,	6
Millbury,	6	Sherborn,	21
Milton,	90	Shirley,	12
Nantucket,	6	Somerset,	12
Natick,	255	Somerville,	1,187
Needham,	18	Southbridge,	6
New Bedford,	1,046	Southampton,	12
Newburyport,	258	Spencer,	30
Newton,	312	Springfield,	375
North Adams,	303	Stoneham,	48
North Andover,	24	Stoughton,	36
North Attleborough,	21	Stow,	24
North Brookfield,	6	Swampscott,	60
North Reading,	6	Swansea,	24
Northampton,	12	Taunton,	236
Northbridge,	6	Topsfield,	9
Northfield,	6	Townsend,	12
Norton,	1	Upton,	6
Norwell,	12	Wakefield,	61
Norwood,	212	Walpole,	4

Number of Bottles of Diphtheria Antitoxin distributed from April 1, 1903, to March 31, 1904 — Concluded.

City or Town.	Number of Bottles.	City or Town.	Number of Bottles.
Waltham,	293	Westwood,	6
Ware,	9	Weymouth,	272
Wareham,	8	Whitinsville,	6
Warren,	30	Whitman,	30
Watertown,	28	Wilbraham,	18
Waverley, Massachusetts School for the Feeble-minded.	6	Williamsburg,	6
Wayland,	12	Williamstown,	12
Webster,	6	Wilmington,	6
Wellesley,	24	Winchester,	110
West Bridgewater,	6	Winthrop,	138
West Medway,	12	Woburn,	94
West Springfield,	36	Worcester,	1,645
Westborough,	6	Worthington,	3
Westfield,	24	Total,	41,133
Westport,	6		

From the foregoing list it appears that the number of packages of antitoxin used in 1903 was greater by 7,658 than the number used in the preceding year, and less by 12,256 than were used in 1900. The number of cities and towns in which more than 100 bottles were used in each was 37.

Summary Observations upon the Use of Diphtheria Antitoxin in Massachusetts during the Year ended March 31, 1904.

The whole number of returns of cases treated with diphtheria antitoxin furnished by the State Board of Health during the year ended March 31, 1904, to hospitals and to local boards of health for use in general practice was 2789. Of this number, 1,834 were returns of cases of diphtheria treated with antitoxin, and 955 were returns of other persons who had been exposed to infection and were treated for the purpose of immunization. These cases constitute only a fraction of those which were treated during the year in the State with antitoxin furnished by the Board, since very many physicians failed to make returns to the Board.

Cases in which a Bacterial Examination was made.

The same methods of classification are continued in this report as were adopted in the reports of the previous eight years. The cases in which cultures were made are classified into positive and negative cases. Diag-

nostic examinations were made in 1,483 cases reported to the Board as having been treated with antitoxin, and of these, 1,390 proved to be genuine cases of diphtheria and 93 gave a negative result.

Positive Cases.

Of the 1,390 positive cases, or those in which a diagnosis of diphtheria was made by bacterial cultures from the throat of the patient, there were 1,277 recoveries and 113 deaths, or 8.1 per cent., the results of the previous years having been, respectively, 13.7, 11.6, 8.2, 7.9, 11.4, 9.4, 10.1 and 9.8 per cent.

Sex. — The number of males was 656 and the deaths of these were 53 or 8.1 per cent. The females were 732, and the deaths of these were 60, or 8.2 per cent.

Ages. — The following table shows the cases and deaths by ages: —

Year ended March 31, 1904.

Age Periods.	Cases.	Deaths.	Fatality (Per Cent.). 1903.	Fatality (Per Cent.). 1902.
From 0 to 2 years,	93	24	25.8	26.9
From 2 to 5 years,	345	45	13.0	11.7
From 5 to 10 years,	421	25	5.9	8.3
Over 10 years,	457	11	2.4	5.0
Age unknown,	74	8	10.8	20.5
	1,390	113	8.1	9.8

Day of Illness when Antitoxin was first administered. — The following table presents the fatality, according to the day of illness on which the antitoxin was first administered: —

Day.	Cases.	Deaths.	Fatality (Per Cent.). 1903.	1902.	1901.	1900.	1899.	1898.	1897.	1896.	1895.
First,	120	4	3.3	9.8	9.5	6.4	9.8	8.2	8.0	0.0	0.0
Second,	354	14	4.0	6.7	6.7	6.0	5.6	1.8	8.9	9.5	9.7
Third,	308	19	6.2	5.5	9.4	7.7	12.8	6.2	7.0	8.3	8.7
Fourth,	198	24	12.1	12.7	12.5	11.3	14.1	13.2	3.0	22.7	15.4
Fifth,	119	21	17.7	19.0	17.0	14.8	15.6	11.8	11.8	0.0	22.2
Sixth,	60	6	10.0	18.0	16.0	21.1	17.9	20.0	0.0	14.3	20.0
Seventh,	23	3	13.0	15.4	18.4	13.7	27.1	9.5	30.0	25.0	33.3*
Eighth and later,	47	4	8.5	17.8	18.5	16.8	14.7	10.4	13.6	16.6	–
Unknown,	161	18	–	–	–	–	–	–	–	–	–

* Seventh day and later.

The value of the foregoing table consists mainly in the definite statement of the fatality of cases according to the day of illness at which antitoxin treatment was begun. In general, it shows that the ratio of success in treatment depends largely upon the early date at which antitoxin is first administered. A fuller and more conclusive summary, embracing the whole period of nine years and containing greater numbers, may be found on a later page.

The cases in which antitoxin treatment was begun either upon the first, second or third days of illness constituted 56.3 per cent. of the whole numcer of positive cases reported to the Board to which antitoxin was administered during the year under consideration.

Hospitals and Private Practice.

	Cases.	Deaths.	Fatality (Per Cent.).
In hospitals,	1,111	100	9.0*
In private practice,	279	13	4.7*

* This apparent difference in the fatality of hospital and of general or outside treatment with antitoxin is accounted for by the fact that a considerable number of severe and fatal cases of diphtheria, which were treated by physicians in general practice, were reported as having been transferred to a hospital after one or more days of home treatment and died at the hospital.

Seasons of the Year. — The cases embraced in the foregoing enumeration occurred in the following order: —

Months.	Cases.	Deaths.	Months.	Cases.	Deaths.
1903.			**1903.**		
April,	62	11	October,	199	15
May,	77	2	November,	189	13
June,	82	3	December,	194	14
July,	79	13	**1904.**		
August,	36	9	January,	182	12
September,	60	3	February,	116	9
			March,	113	9
Total six months,	396	41	Total six months,	993	72

By the foregoing table it appears that there were 396 positive cases reported in the warmer months, with 41 deaths, and 993 cases in the colder months, with 72 deaths. In 1 case the date was not given.

Negative Cases.

The reported cases in which a negative result was obtained were 93, and the deaths of these were 15, or 16.1 per cent.

Sex. — The males were 40, with 7 deaths, or 17.5 per cent., and the females 51, with 8 deaths, or 15.7 per cent.

Age. — The percentage of fatality at each of four age periods was as follows: 0 to 2 years, 35.7 per cent.; 2 to 5 years, 26.1 per cent.; 5 to 10 years, 5.3 per cent.; and all over 10 years, 9.7 per cent.

Summary of the Nine Years ended March 31, 1904.

Positive Cases treated with Antitoxin.

Whole number of positive cases for the nine years, 12,945; deaths, 1,261; fatality, 9.7 per cent.

Sex. — The fatality by sexes was as follows: —

Sex.	Cases.	Deaths.	Fatality (Per Cent.).
Males,	6,090	630	10.3
Females,	6,753	615	9.1

The sex of 102 was not stated; 16 deaths.

Ages. — The fatality by ages was as follows: —

Age Periods.	Cases.	Deaths.	Fatality (Per Cent.).
0 to 2 years,	1,377	309	22.4
2 to 5 years,	4,001	508	12.7
5 to 10 years,	3,783	267	7.1
Over 10 years,	3,355	120	3.6
Age unknown,	429	57	–

Hospitals and Private Practice.

	Cases.	Deaths.	Fatality (Per Cent.).
In hospitals,	9,242	990	10.7
In private practice,	3,703	268	7.2

Cases in which no Bacteriological Examination was made during the Year ended March 31, 1904.

Reports were received of 351 cases where antitoxin was employed in which no cultures were taken. Of this number 262, or 74.6 per cent., occurred in general practice and the remainder were reported from hospitals. Of the whole number, 47 proved fatal, or 13.4 per cent.

Sex. — The number of males in this class was 164, and the deaths of these were 23, or 14 per cent. The number of females was 185, and the deaths of these were 24, or 13 per cent. The number of those whose sex was unknown or not stated was 2.

Age. — The following table presents the cases and fatality by ages among this class so far as observations were made : —

Age Periods.	Cases.	Deaths.	Fatality (Per Cent.).
From 0 to 2 years,	40	15	37.5
From 2 to 5 years,	78	20	25.6
From 5 to 10 years,	84	7	8.3
Over 10 years,	68	3	4.4
Age unknown,	7	2	–

The higher fatality of this class is explained by the fact that many of the cases embraced in the returns are described as "moribund" or "beyond help" or "in extremis" when antitoxin was administered. They were consequently beyond the reach of remedial aid, and in many of them it was impracticable to make a bacterial diagnosis.

Sequelæ.

Temporary skin eruptions, usually of brief duration, are of very common occurrence after the administration of antitoxin. Frequently these eruptions are quite mild and confined to a small area adjoining the place of injection, while occasional instances occur in which the eruption spreads throughout the entire surface of the body, or at least a portion of its area.

During the year under consideration such eruptions or rashes are reported as occurring in 523 instances, or 28.5 per cent. of the whole number reported upon. Of this number, 94 per cent. were mild in character and the remainder severe or extensive.

Albuminuria was reported in 75 instances, of which 66 were slight, or consisted of a trace only. The presence of albuminuria, however, has no significance as relating to the administration of antitoxin, since albuminuria is present according to good authorities in the majority of severe cases of diphtheria.*

Operations.

Tracheotomy, an operation which was once quite commonly resorted to in severe cases of laryngeal diphtheria, appears to have been largely supplanted by the more safe and simple operation of intubation. It is reported as having been performed 7 times during the year, with 5 deaths.

* Osler's "Practice of Medicine," 2d edition, page 115.

Intubation is reported as having been performed 136 times during the year, with 43 deaths, or 31.6 per cent.

The different diseases which are met with as complications of diphtheria independently of the use of antitoxin appear to depend for their frequency largely upon the relative prevalence of these diseases throughout the State. Scarlet fever and measles having been more or less prevalent in 1903, these diseases were occasionally met with in the hospitals as complications with diphtheria. Scarlet fever was reported as a complication in 28 instances and measles in 10. In most instances the complication adds to the severity of the cases and increases the fatality, but not to so great an extent as when pneumonia supervenes. Pneumonia and broncho-pneumonia were reported as complications in 24 cases, many of which proved fatal.

The most important lesson, repeated in former reports, to which the experience of each successive year adds emphasis, is the necessity of the early administration of antitoxin in each and every case.

Immunization.

Returns of cases in which antitoxin had been used for the purpose of the immunization of persons who had been exposed to the infection of diphtheria were received in 955 cases. Of this number, 840 were cases which had been exposed to diphtheria and had been immunized in the isolation wards of the Boston City Hospital and chiefly in the scarlet-fever ward.

Out of the whole number of 955 thus immunized, 15, or 1.6 per cent., were reported as having contracted diphtheria at some time within two months after immunization.

Of these cases one was found to have diphtheria on the sixth day after immunization, one on the eleventh day, one on the nineteenth, one on the twenty-fifth, two on the twenty-eighth, one on the twenty-ninth, one on the thirty-second, one on the fortieth, one on the forty-third, two on the forty-fifth day, two at the end of two months, and in one case the interval was not stated.

In this connection, a recent report of the Imperial Health Board of Germany is worthy of comment.* This board reports the results of immunization of 31,740 persons who had been exposed to the infection of diphtheria. Out of this number, 897 subsequently became ill with diphtheria. The interval which elapsed, however, between the date of immunization and the time of the appearance of symptoms of diphtheria was so variable (from four hours to two years) as to seriously impair the value of the observations. Many of the cases were those of persons in whom the disease appeared at so short a time after immunization as to justify the belief that the infection had been received at some time prior to the time of such immunization.

* Ergebnisse einer Umfrage bei Ärzten des Deutschen Reiches, betr. die Erfolge der Schutzimpfungen mit Diphtherieserum. Berlin, 1903.

GENERAL SUMMARY, 1895-1904.

Positive cases treated in the nine years ending March 31, 1904, and reported to the State Board of Health,	12,945
Cases in which no bacteriological examination was made,	3,274
Total,	16,219*
Deaths of these,	1,676
Fatality (per cent),	10.3

Sexes.

The number of males who were treated was †	7,575
The number of females who were treated was †	8,477
The number whose sex was not stated was †	167
Total,	16,219*
Deaths of males,	831
Fatality of males (per cent.),	10.9
Deaths of females,	820
Fatality of females (per cent.),	9.7
Deaths, sex not stated,	25

The following table contains the results of those cases only which had been determined by a culture examination to be positive, with reference to the fatality of the disease in each group of cases, considered in relation to the stage of the disease when antitoxin was first administered.

Nothing can be more conclusive than the cumulative testimony of these figures, supported as they are by similar experience elsewhere, as to the importance of the earliest possible administration of antitoxin in the treatment of diphtheria. Each day's delay renders the liability to a fatal result greater.

The fatality of the cases which were treated with antitoxin very early in the course of the disease (that is, before the termination of forty-eight hours from its onset) was only 6.5‡ per cent., or 335 deaths in 5,191 cases, while that of the cases which were not thus treated until the sixth day or later was as high as 17.0 per cent., or nearly three times as great.

* In this number (16,219) 1,563 cases in which a bacterial diagnosis showed negative results are not included, so that the whole number treated with antitoxin of which returns were made to the Board was 17,782.

† Except cases determined to be "negative."

‡ The sum of the experience of the first two days is expressed in this figure.

Day of Administration.

Day.	Cases.	Deaths.	Fatality (Per Cent.).
First,	1,553	118	7.6
Second,	3,638	217	6.0
Third,	2,962	258	8.7
Fourth,	1,885	242	12.8
Fifth,	983	158	16.1
Sixth and later,	1,372	233	17.0

A considerable number of cases and deaths, in which the day of administration was not stated in the returns, is excluded from this table.

The following table, furnished by Dr. J. H. McCollom, in charge of the isolating wards of the Boston City Hospital, presents the experience of that institution with reference to the fatality of diphtheria before and after the introduction of serum treatment. The statistics relative to intubations are also given in the same table.

Number of Cases of Diphtheria treated at the Boston City Hospital Proper, and at the South Department, from 1888 to 1903, inclusive. Number of Cases of Intubation for the Same Time.

Year.	Number of Cases of Diphtheria	Died.	Per Cent. of Mortality.	Per Cent. of Recoveries.	Number of Intubations	Died.	Per Cent. of Mortality.	Per Cent. of Recoveries.
1888 to 1894, No Antitoxin.								
1888,	382	176	46.07	53.92	100	78	78.00	22.00
1889,	529	239	45.17	54.82	128	104	81.25	18.75
1890,	415	151	36.38	63.61	93	79	84.94	15.05
1891,	237	105	44.30	55.69	50	42	84.00	16.00
1892,	387	185	47.80	52.19	65	56	86.15	13.84
1893,	419	203	48.44	51.55	109	90	82.56	17.43
1894,	698	266	38.10	61.89	89	74	83.14	16.85
Total,	3,067	1,325	43.20	56.80	634	523	82.50	17.50
1895 to 1903, Antitoxin.								
1895,	1,455	207	14.22	85.77	118	64	54.23	45.76
1896,	1,889	276	14.61	85.38	224	145	64.73	35.26
1897,	1,387	181	13.04	86.95	146	67	45.88	54.11
1898,	817	97	11.87	88.12	71	42	59.15	40.84
1899,	1,621	162	10.00	90.00	192	63	32.81	67.18
1900,	2,547	293	11.50	88.49	259	87	33.59	66.40
1901,	1,576	185	11.73	88.26	184	58	31.52	68.47
1902,	1,008	111	10.20	89.79	145	49	33.79	66.20
1903,	1,179	138	11.70	88.29	139	37	26.61	73.38
Total,	13,479	1,650	12.24	87.76	1,478	612	41.41	58.59

REPORT UPON DIPHTHERIA CULTURES EXAMINED DURING THE YEAR ENDED MARCH 31, 1904.

During the year ended March 31, 1904, 3,632 cultures have been received from 137 towns and cities in the State. Of these cultures 1,415 were made for the purpose of diagnosis and 2,217 were for release from quarantine. The following table gives the number of cultures received from the different towns and cities and the results of the examinations: —

City or Town.	Whole Number of Cultures examined.	Cultures examined for Diagnosis.			Cultures examined for Release from Quarantine.
		Positive.	Negative.	Doubtful.	
Abington,	13	3	3	0	7
Acton,	2	1	–	–	1
Adams,	10	3	3	–	4
Amesbury,	1	–	1	–	–
Andover,	12	6	6	–	–
Arlington,	228	17	32	1	178
Ashland,	2	1	–	–	1
Athol,	1	–	1	–	–
Attleborough,	7	4	1	1	1
Avon,	8	2	1	–	5
Ayer,	1	–	1	–	–
Barnstable,	9	2	4	–	3
Belchertown,	1	1	–	–	–
Belmont,	1	–	1	–	–
Berlin,	1	–	1	–	–
Beverly,	43	12	14	–	17
Billerica,	2	–	2	–	–
Boston,	4	–	–	–	4
Bourne,	4	1	2	–	1
Boxborough,	5	–	1	–	4
Braintree,	16	2	8	1	5
Bridgewater,	1	–	1	–	–
Brockton,	2	1	1	–	–
Brookfield,	3	1	1	1	–
Cambridge,	4	2	1	–	1
Canton,	59	1	3	–	55
Chelsea,	37	5	18	1	13
Chelmsford,	1	–	1	–	–
Clinton,	11	2	7	–	2

City or Town.	Whole Number of Cultures examined.	Cultures examined for Diagnosis.			Cultures examined for Release from Quarantine.
		Positive.	Negative.	Doubtful.	
Cohasset,	23	5	1	-	17
Concord,	20	2	17	-	1
Danvers,	16	2	6	-	8
Dartmouth,	2	1	1	-	-
Dedham,	18	3	10	-	5
Duxbury,	5	1	1	-	3
East Bridgewater,	3	-	1	-	2
Easton,	11	-	4	-	7
Edgartown,	1	-	1	-	-
Everett,	105	7	21	-	77
Falmouth,	2	-	2	-	-
Foxborough,	27	1	20	-	6
Framingham,	15	5	5	-	5
Gloucester,	9	4	5	-	-
Groton,	4	1	-	-	3
Hanover,	8	1	2	-	5
Hanson,	1	-	1	-	-
Haverhill,	6	1	4	-	1
Hingham,	8	-	8	-	-
Holbrook,	25	2	13	-	10
Hopedale,	3	-	2	1	-
Hopkinton,	7	2	3	-	2
Hyde Park,	31	2	9	-	20
Ipswich,	2	-	1	-	1
Kingston,	1	-	1	-	-
Lancaster,	3	-	-	-	3
Lawrence,	43	14	16	-	13
Leicester,	1	-	1	-	-
Leominster,	4	-	4	-	-
Lexington,	1	-	1	-	-
Lincoln,	1	-	1	-	-
Littleton,	3	2	-	-	1
Lunenburg,	1	-	1	-	
Lynn,	58	5	5		48
Lynnfield,	1	-	1	-	-
Malden,	305	25	40	-	240
Mansfield,	4	1	2	-	1
Marblehead,	177	31	32	-	114
Marion,	2	-	2	-	-
Marlborough,	299	42	33	-	224
Marshfield,	122	14	15	-	93
Medfield,	2	-	2	-	-
Medford,	111	18	42	1	50
Medway,	14	2	1	-	11
Melrose,	69	8	15	-	46
Mendon,	1	-	1	-	-
Methuen,	2	1	1	-	-
Middleborough,	1	-	1	-	-
Milford,	3	-	3	-	-
Milton,	81	8	30	1	42
Millis,	3	-	3	-	-

City or Town.	Whole Number of Cultures examined.	Cultures examined for Diagnosis.			Cultures examined for Release from Quarantine.
		Positive.	Negative.	Doubtful.	
Natick,	85	25	28	-	32
Needham,	6	1	5	-	-
Newbury,	1	-	1	-	-
Newburyport,	75	11	35	1	28
North Adams,	231	31	31	1	168
North Attleborough,	13	4	6	-	3
Northborough,	5	-	-	-	5
Northfield,	2	-	1	-	1
Norton,	1	-	1	-	-
Norwell,	14	-	5	-	9
Norwood,	8	4	4	-	-
Peabody,	52	4	7	-	41
Pittsfield,	19	1	7	-	11
Plymouth,	2	1	1	-	-
Provincetown,	29	7	3	-	19
Quincy,	47	6	23	-	18
Randolph,	10	2	4	1	3
Reading,	14	1	9	-	4
Revere,	28	5	13	-	10
Rockland,	25	4	7	-	14
Rockport,	15	3	9	-	3
Salem,	346	30	36	1	279
Salisbury,	1	-	1	-	-
Saugus,	15	1	8	-	6
Scituate,	31	6	8	-	17
Sherborn,	7	4	2	-	1
Shirley,	1	-	1	-	-
Southborough,	4	2	-	-	2
Southbridge,	2	-	1	-	1
Spencer,	6	-	-	-	6
Stockbridge,	4	1	2	-	1
Stoneham,	5	-	5	1	-
Stoughton,	38	8	3	-	27
Swampscott,	21	2	8	-	11
Taunton,	16	4	2	-	10
Wakefield,	8	-	7	-	1
Walpole,	11	2	5	1	3
Wareham,	2	1	1	-	-
Warren,	38	8	10	1	19
Watertown,	18	3	10	-	5
Wayland,	2	-	1	-	1
Wellesley,	7	-	6	-	1
Westborough,	4	1	2	-	1
West Brookfield,	1	-	-	-	1
West Bridgewater,	1	-	-	-	1
Westford,	2	1	1	-	-
Westport,	1	-	-	-	1
Westwood,	4	-	-	-	4
Weymouth,	25	6	13	-	6
Whitman,	1	1	-	-	-
Williamstown,	8	1	3	1	3

City or Town.	Whole Number of Cultures examined.	Cultures examined for Diagnosis.			Cultures examined for Release from Quarantine.
		Positive.	Negative.	Doubtful.	
Wilmington, ...	2	–	2	–	–
Winchendon, ...	5	2	1	–	2
Winchester, ...	75	11	35	4	25
Winthrop, ...	78	14	15	–	49
Woburn, ...	15	–	14	–	1
Not stated, ...	1	–	–	–	1
Total, ...	3,632	487	909	19	2,217

Persistence of Diphtheria in the Throats of Patients Convalescent from Diphtheria.

Among these cases are included only those in which frequent cultures were made until the throat was free from the bacilli. The time of persistence is given from the date of the earliest symptoms to when the bacilli were last found in cultures from the throat.

Time of Persistence.	Number of Cases.	Time of Persistence.	Number of Cases.
1 week or less, . .	47	7 to 8 weeks, . .	9
1 to 2 weeks, . . .	71	8 to 9 weeks, . .	3
2 to 3 weeks, . . .	94	9 to 10 weeks, . .	1
3 to 4 weeks, . . .	74	10 to 11 weeks, . .	–
4 to 5 weeks, . . .	41	11 to 12 weeks, . .	1
5 to 6 weeks, . . .	16	18 to 19 weeks, . .	1
6 to 7 weeks, . . .	9		

Relation of Clinical to Bacteriological Diagnosis.

Clinical Diagnosis.	Bacteriological Diagnosis.		
	Positive.	Negative.	Doubtful.
Positive in 486 cases, ...	255	226	5
Negative in 279 cases, ...	33	243	3
Doubtful in 398 cases, ...	118	274	6
Not given in 252 cases, ...	81	166	5
Total, ...	487	909	19

Relation of Bacteriological Diagnosis to the Day of Taking the Culture.

Day of Disease on which Culture was Taken.	Bacteriological Diagnosis.			Percentage of Positive Cases.
	Positive.	Negative.	Doubtful.	
First day,	24	32	4	40.0
Second day,	181	308	4	36.7
Third day,	112	271	5	28.8
Fourth day,	61	123	2	32.7
Fifth day,	37	57	2	38.5
Sixth day,	18	33	-	35.2
Seventh day,	13	24	-	35.1
Over seven days,	25	26	1	48.0
Not stated,	16	35	1	30.7
Total,	487	909	19	34.4

SUMMARY OF THE EIGHT YEARS ENDED MARCH 31, 1904.

The whole number of cultures examined during the eight years is as follows: —

In 1896-97 (year ended March 31, 1897),	1,469
In 1897-98 (year ended March 31, 1898),	2,204
In 1898-99 (year ended March 31, 1899),	1,591
In 1899-1900 (year ended March 31, 1900),	3,258
In 1900-1901 (year ended March 31, 1901),	5,173
In 1901-1902 (year ended March 31, 1902),	4,119
In 1902-1903 (year ended March 31, 1903),	2,904
In 1903-1904 (year ended March 31, 1904),	3,632
Total,	24,350

Of these 24,350 cultures 10,983 were made for the purpose of diagnosis and 13,367 for release from quarantine. Of the cultures made for diagnosis 4,533 were positive, 6,273 were negative and 177 were doubtful.

In 10,983 cultures examined for diagnosis the relation of clinical to bacteriological diagnosis was as follows: —

Clinical Diagnosis.	Bacteriological Diagnosis.		
	Positive.	Negative.	Doubtful.
Positive in 3,982 cases,	2,480	1,453	49
Negative in 2,227 cases,	402	1,789	36
Doubtful in 2,845 cases,	950	1,851	44
Not given in 1,929 cases,	701	1,180	48

REPORT UPON EXAMINATIONS OF SPUTUM AND OTHER MATERIAL SUSPECTED OF CONTAINING THE BACILLI OF TUBERCULOSIS.

During the year ended March 31, 1904, microscopical examination has been made of 1,006 specimens of sputum and other material suspected of containing the bacilli of tuberculosis. This material was received from 126 different towns and cities in the State. The following table gives the places from which the material was received and the results of the examinations: —

City or Town.	Number of Cases examined.	Males.			Females.			Sex not stated.			Re-examinations.		
		Positive.	Negative.	Doubtful.	Positive.	Negative.	Doubtful.	Positive.	Negative.	Doubtful.	Positive.	Negative.	Doubtful.
Abington,	2	-	1	-	-	1	-	-	-	-	-	-	-
Acton,	3	-	1	-	1	1	-	-	-	-	-	-	-
Adams,	8	1	1	-	4	1	-	-	-	-	1	-	-
Andover,	6	-	3	-	-	3	-	-	-	-	-	-	-
Arlington,	9	-	3	-	1	4	-	-	-	-	-	1	-
Ashland,	2	1	-	-	-	1	-	-	-	-	-	-	-
Attleborough,	20	3	4	-	3	10	-	-	-	-	-	-	-
Avon,	9	1	-	-	4	3	-	-	-	-	1	-	-
Barnstable,	3	1	-	-	1	1	-	-	-	-	-	-	-
Barre,	3	1	-	-	-	-	-	1	-	-	-	1	-
Belmont,	3	1	1	-	-	-	-	-	-	-	-	1	-
Beverly,	1	-	-	-	1	-	-	-	-	-	-	-	-
Billerica,	1	-	-	-	-	1	-	-	-	-	-	-	-
Blackstone,	8	5	1	-	-	2	-	-	-	-	-	-	-
Boston,	10	2	3	-	1	3	-	-	1	-	-	-	-
Bourne,	1	-	-	-	1	-	-	-	-	-	-	-	-
Boxford,	2	-	-	-	-	2	-	-	-	-	-	-	-
Braintree,	4	-	2	-	-	2	-	-	-	-	-	-	-
Bridgewater,	2	-	1	-	-	1	-	-	-	-	-	-	-
Brockton,	2	-	-	-	-	2	-	-	-	-	-	-	-
Brookfield,	6	-	1	-	-	4	-	-	-	-	-	1	-
Cambridge,	6	1	-	-	2	1	-	-	2	-	-	-	-
Charlemont,	1	-	-	-	-	1	-	-	-	-	-	-	-
Chelmsford,	2	-	1	-	-	-	-	-	1	-	-	-	-
Chelsea,	7	4	-	-	-	2	-	1	-	-	-	-	-
Clinton,	11	1	2	-	2	3	1	1	1	-	-	-	-
Colrain,	1	-	-	-	1	-	-	-	-	-	-	-	-
Concord,	18	5	6	-	3	3	-	-	1	-	-	-	-

City or Town.	Number of Cases examined.	Males.			Females.			Sex not stated.			Re-examinations.		
		Positive.	Negative.	Doubtful.	Positive.	Negative.	Doubtful.	Positive.	Negative.	Doubtful.	Positive.	Negative.	Doubtful.
Danvers, . . .	9	1	2	–	2	3	–	–	1	–	–	–	–
Dedham, . . .	10	3	4	–	2	1	–	–	–	–	–	–	–
Dighton, . . .	1	–	–	–	–	1	–	–	–	–	–	–	–
Easton, . . .	1	–	–	–	–	1	–	–	–	–	–	–	–
East Bridgewater, .	1	-	1	–	–	–	–	–	–	–	–	–	–
Everett, . . .	47	7	16	–	6	13	–	1	1	–	1	2	–
Fall River, . .	121	18	36	–	24	36	–	4	3	–	–	–	–
Foxborough, . .	9	2	1	–	–	6	–	–	–	–	–	–	–
Framingham, . .	10	3	–	1	2	3	–	–	1	–	–	–	–
Gloucester, . .	2	–	2	–	–	–	–	–	–	–	–	–	–
Great Barrington, .	3	1	–	–	1	1	–	–	–	–	–	–	–
Greenfield, . .	5	1	2	–	1	1	–	–	–	–	–	–	–
Hanover, . .	1	–	1	–	–	–	–	–	–	–	–	–	–
Hanson, . . .	1	–	–	–	1	–	–	–	–	–	–	–	–
Hardwick, . .	1	–	–	–	1	–	–	–	–	–	–	–	–
Haverhill, . .	6	1	–	–	1	3	–	–	1	–	–	–	–
Hingham, . .	8	2	4	–	–	1	–	–	1	–	–	–	–
Holbrook, . .	3	–	–	–	–	3	–	–	–	–	–	–	–
Hudson, . . .	3	–	1	–	1	1		–	–	–	–	–	–
Hyde Park, . .	19	1	5	–	3	9	–	1	–	–	–	–	–
Lancaster, . .	2	1	–	–	–	1	–	–	–	–	–	–	–
Lawrence, . .	25	5	9	–	4	6	–	–	–	–	1	–	–
Lexington, . .	7	–	–	–	1	5	–	1	–	–	–	–	–
Lincoln, . . .	1	–	–	–	–	1	–	-	–	–	–	–	–
Littleton, . .	4	–	2	–	–	2	–	–	–	–	–	–	–
Lynn, . . .	4	1	3	–	–	–	–	–	–	–	–	–	–
Malden, . . .	17	5	6	–	2	3	–	–	1	–	–	–	–
Mansfield, . .	3	1	–	–	1	1	–	–	–	–	–	–	-
Marlborough, . .	8	1	1	–	1	5	–	–	–	–	–	–	–
Marshfield, . .	6	1	1	–	2	2	–	–	–	–	–	–	–
Maynard, . .	2	–	–	–	1	1	–	–	–	–	–	–	–
Medford, . .	21	5	5	–	3	7	–	–	–	–	–	1	–
Medway, . .	3	–	1	–	–	2	–	–	–	–	–	-	–
Melrose, . . .	17	2	3	1	4	5	–	–	2	–	–	–	-
Merrimac, . .	1	–	–	–	–	1	–	–	–	–	–	–	–
Methuen, . .	3	–	1	–	1	1	–	–	–	–	–	–	–
Middleborough, .	12	2	3	–	3	2	–	–	1	–	–	1	–
Middleton, . .	1	–	–	–	1	–	–	–	–	–	–	–	–
Milford, . . .	2	–	–	–	–	1	–	–	1	–	–	–	–
Milton, . . .	7	1	2	–	1	3	–	–	–	–	–	–	–
Millis, . . .	3	-	–	–	–	2	–	–	–	–	–	1	–
Monroe, . . .	1	–	–	–	–	1	–	–	–	–	–	–	–
Natick, . . .	13	2	5	–	4	2	–	–	–	–	–	–	–
Needham, . .	8	–	3	–	–	5	–	–	–	–	–	–	–
New Bedford, .	3	2	–	–	1	–	–	–	–	–	–	–	–
Newburyport, .	2	–	–	–	–	2	–	–	–	–	–	–	–
Newton, . . .	5	–	3	–	–	2	–	–	–	–	–	–	–
North Adams, .	41	3	15	–	7	14	1	–	–	–	–	1	–
North Attleborough,	12	3	5	–	1	3	–	–	–	–	–	–	–
North Brookfield, .	1	–	1	–	–	–	–	–	–	–	–	–	–
Northfield, . .	1	1	–	–	–	–	–	–	–	–	–	–	–

City or Town.	Number of Cases examined.	Males.			Females.			Sex not stated.			Re-examinations.		
		Positive.	Negative.	Doubtful.	Positive.	Negative.	Doubtful.	Positive.	Negative.	Doubtful.	Positive.	Negative.	Doubtful.
Norton,	2	1	–	–	–	1	–	–	–	–	–	–	–
Norwood,	4	1	1	–	1	1	–	–	–	–	–	–	–
Palmer,	2	–	1	–	–	1	–	–	–	–	–	–	–
Peabody,	33	4	7	–	6	14	–	–	1	–	–	1	–
Quincy,	65	9	18	–	9	17	–	1	1	–	3	7	–
Randolph,	9	2	5	–	1	1	–	–	–	–	–	–	–
Reading,	12	1	4	–	1	5	–	–	–	–	–	1	–
Revere,	18	2	6	–	1	9	–	–	–	–	–	–	–
Rockland,	14	3	5	–	–	6	–	–	–	–	–	–	–
Salem,	31	5	5	–	9	12	–	–	–	–	–	–	–
Scituate,	5	–	–	–	2	3	–	–	–	–	–	–	–
Sharon,	1	–	–	–	–	–	–	–	1	–	–	–	–
Sherborn,	1	–	–	–	1	–	–	–	–	–	–	–	–
Shirley,	2	–	1	–	–	1	–	–	–	–	–	–	–
Somerville,	2	–	1	–	–	–	–	–	–	–	–	1	–
Southampton,	1	1	–	–	–	–	–	–	–	–	–	–	–
Southborough,	1	–	1	–	–	–	–	–	–	–	–	–	–
Spencer,	10	1	3	–	1	4	–	–	–	–	–	1	–
Sterling,	1	–	–	–	1	–	–	–	–	–	–	–	–
Stow,	1	1	–	–	–	–	–	–	–	–	–	–	–
Swampscott,	1	–	–	–	1	–	–	–	–	–	–	–	–
Taunton,	36	9	6	–	10	11	–	–	–	–	–	–	–
Topsfield,	1	–	1	–	–	–	–	–	–	–	–	–	–
Tyngsborough,	2	–	–	–	1	1	–	–	–	–	–	–	–
Wakefield,	2	–	1	–	–	1	–	–	–	–	–	–	–
Walpole,	1	–	1	–	–	–	–	–	–	–	–	–	–
Waltham,	1	–	1	–	–	–	–	–	–	–	–	–	–
Warren,	14	2	2	–	1	9	–	–	–	–	–	–	–
Watertown,	3	1	–	–	–	1	–	–	–	–	1	–	–
Wayland,	1	–	–	–	1	–	–	–	–	–	–	–	–
Wellesley,	7	–	1	–	2	4	–	–	–	–	–	–	–
Westborough,	1	–	1	–	–	–	–	–	–	–	–	–	–
West Brookfield,	2	–	1	–	–	–	–	–	1	–	–	–	–
Westford,	10	–	3	–	1	4	–	–	–	–	2	–	–
West Newbury,	1	–	–	–	–	1	–	–	–	–	–	–	–
Weston,	1	–	–	–	–	1	–	–	–	–	–	–	–
Weymouth,	3	–	2	–	–	1	–	–	–	–	–	–	–
Whitman,	4	1	1	–	–	1	–	–	1	–	–	–	–
Williamstown,	4	1	2	–	1	–	–	–	–	–	–	–	–
Wilmington,	4	–	1	–	1	1	–	–	–	–	1	–	–
Winchendon,	3	1	–	–	1	1	–	–	–	–	–	–	–
Winchester,	18	–	5	1	3	8	–	–	–	–	–	1	–
Winthrop,	4	–	1	–	–	3	–	–	–	–	–	–	–
Woburn,	11	1	4	–	4	2	–	–	–	–	–	–	–
Worcester,	1	–	–	–	–	1	–	–	–	–	–	–	–
Wrentham,	3	1	–	–	–	2	–	–	–	–	–	–	–
Not stated,	4	1	1	–	1	1	–	–	–	–	–	–	–
Total,	1,006	152	268	3	169	344	2	11	24	–	11	22	–

Ages. — The relation of bacteriological diagnosis to age is shown in the following table: —

Age Periods.	Number of Cases examined.	Positive.	Negative.	Doubtful.	Percentage of Positive Cases.
From 0 to 10 years, . . .	22	-	22	-	00.0
From 10 to 20 years, . . .	124	47	76	1	38.7
From 20 to 30 years, . . .	304	128	174	2	42.1
From 30 to 40 years, . . .	244	84	159	1	34.4
From 40 to 50 years, . . .	131	34	97	-	25.9
From 50 to 60 years, . . .	71	19	52	-	26.7
From 60 to 70 years, . . .	33	9	24	-	27.2
From 70 to 80 years, . . .	12	1	11	-	8.3
From 80 to 90 years, . . .	1	-	1	-	00.0
Age not stated, ...	64	21	42	1	32.8
Total, ...	1,006	343	658	5	34.0

Sex. — The relation of bacteriological diagnosis to sex is shown in the following table: —

Bacteriological Diagnosis.	Total.	Males.	Females.	Sex not stated.
Positive cases, ...	343	156	176	11
Negative cases, ...	658	281	353	24
Doubtful cases, ...	5	3	2	-
Total, ...	1,006	440	531	35

Clinical Diagnosis. — The relation of clinical diagnosis to bacteriological diagnosis is as follows: —

Clinical Diagnosis.	Bacteriological Diagnosis.		
	Positive.	Negative.	Doubtful.
Positive in 390 cases, ...	171	216	3
Negative in 209 cases, ...	38	171	-
Doubtful in 254 cases, ...	86	168	-
Not given in 153 cases, ...	48	103	2
Total in 1,006 cases, ...	343	658	5

Duration of Disease. — The relation of bacteriological diagnosis to the duration of the disease is shown below: —

Duration of Disease to the Time of Examination of Sputum.	Bacteriological Diagnosis.			Percentage of Positive Cases.
	Positive.	Negative.	Doubtful.	
1 month or less,	37	120	-	23.5
1 to 2 months,	38	87	1	30.1
2 to 3 months,	58	92	-	38.6
3 to 6 months,	73	71	-	50.6
6 to 9 months,	17	17	-	50.0
9 to 12 months,	39	47	-	45.3
1 to 2 years,	18	22	-	45.0
Over 2 years,	16	53	-	23.1
Not given,	47	149	4	23.5
Total,	343	658	5	34.0

Summary of the Eight Years ended March 31, 1904.

The number of specimens of sputum and other material examined for the bacilli of tuberculosis during the eight years ended March 31, 1904, is as follows: —

In 1896-1897 (year ended March 31, 1897),	124
In 1897-1898 (year ended March 31, 1898),	236
In 1898-1899 (year ended March 31, 1899),	414
In 1899-1900 (year ended March 31, 1900),	571
In 1900-1901 (year ended March 31, 1901),	746
In 1901-1902 (year ended March 31, 1902),	797
In 1902-1903 (year ended March 31, 1903),	928
In 1903-1904 (year ended March 31, 1904),	1,006
Total,	4,822

Of these 4,822 specimens, 1,910, or 39.6 per cent., contained the bacilli of tuberculosis, in 2,857 specimens the bacilli were not found and in 55 specimens the bacteriological diagnosis was doubtful.

Ages. — Of 728 specimens from persons who were under twenty years of age 35.7 per cent. were positive; of the 3,114 specimens from persons who were between the ages of twenty and fifty years 42.6 per cent. were positive; and of the 520 specimens from persons who were over fifty years of age 24.2 per cent. were positive. The age was not given in 460 cases. Of the positive cases, 260, or 13.6 per cent., were under twenty years of age; 1,327, or 74.7 per cent., were between twenty and fifty years of age; 126, or 6.5 per cent. were over fifty years of age; and in 197 cases the age was not stated.

Sex. — Of the 4,822 cases from which material was examined, 2,212 were males, 2,367 were females and the sex was not stated in 243. Of the male cases 41.4 per cent. and of the female cases 33.4 per cent. were positive.

TYPHOID FEVER.

Widal, Agglutinative or Serum Test.

During the year the method for collecting blood for the Widal or agglutinative test described in the report for 1900 continued to be used.

The blood specimens examined are given in the two following tables. In the first they are grouped according to towns. The whole number of specimens received is given and divided into positive and negative, according to the outcome of the test. Sixty-seven towns sent to the laboratory 303 specimens, of which 77 were positive and 226 negative.

In the second table the results of the examination are arranged according to the day of the disease on which the blood was collected. From this table it will be seen that positive cases were not encountered until the fourth day of the disease. Since the agglutination reaction may not appear until the second week of the disease, or even later, the blood of cases examined with negative result during the first week should be again examined in the second or third week.

The discovery in different countries of a considerable number of cases of disease closely simulating typhoid fever, but responding negatively to the Widal test with typhoid bacilli, has led to the discovery of a group of bacilli, presumably the cause of these attacks, which resemble the typhoid bacillus but are readily distinguished from it by certain bio-chemical tests. At present the laboratory is not in position to recognize such types of disease. In order to make a diagnosis it would be necessary to test a series of these so-called paratyphoid and paracolon bacilli with the blood, which would have to be sent in considerably larger amounts than is needed for the simple test with the typhoid bacillus.

Fortunately, these aberrant typhoid-like affections are milder than genuine typhoid and as a rule non-fatal.

Typhoid Fever (Widal Test) April 1, 1903, to March 31, 1904, inclusive.

City or Town.	Number of Cases.	Positive.	Negative.	City or Town.	Number of Cases.	Positive.	Negative.
Acton,	1	1	-	Bellingham,	1	1	-
Attleborough,	3	2	1	Boston,	7	2	5
Barnstable,	3	1	2	Cambridge,	3	-	3
Bedford,	5	2	3	Chelsea,	3	1	2

Typhoid Fever (Widal Test) April 1, 1903, to March 31, 1904, inclusive. — Concluded.

City or Town.	Number of Cases.	Positive.	Negative.	City or Town.	Number of Cases.	Positive.	Negative.
Clinton, . . .	1	-	1	Millis, . . .	2	-	2
Concord, . . .	10	2	8	Milton, . . .	11	2	9
Cottage City, . .	1	1	-	Natick, . . .	3	-	3
Danvers, . . .	2	-	2	Needham, . . .	17	3	14
Dedham, . . .	1	-	1	Newburyport, . .	10	4	6
Duxbury, . . .	2	-	2	Newton, . . .	2	-	2
Easton, . . .	1	-	1	Norwood, . . .	1	1	-
Edgartown, . .	1	-	1	Quincy, . . .	1	-	1
Everett, . . .	3	-	3	Randolph, . .	1	-	1
Foxborough, . .	3	-	3	Reading, . . .	15	5	10
Gloucester, . .	5	2	3	Revere, . . .	8	-	8
Groton, . . .	1	-	1	Salem, . . .	1	-	1
Hingham, . . .	1	-	1	Scituate, . . .	4	2	2
Holden, . . .	6	-	6	Somerville, . .	17	5	12
Hyde Park, . .	7	2	5	Stoughton, . .	3	1	2
Kingston, . . .	9	6	3	Swampscott, . .	8	-	8
Lancaster, . .	2	-	2	Taunton, . . .	4	1	3
Lawrence, . .	3	2	1	Topsfield, . .	2	-	2
Leominster, . .	3	-	3	Watertown, . .	1	-	1
Lexington, . .	1	-	1	Wayland, . . .	1	-	1
Lowell, . . .	1	1	-	Wellesley, . .	4	-	4
Lynn, . . .	24	7	17	Westport, . .	1	1	-
Lynnfield, . .	2	2	-	Westwood, . .	1	-	1
Malden, . . .	1	-	1	Weymouth, . .	4	-	4
Marblehead, . .	1	-	1	Williamstown, . .	17	10	7
Marlborough, . .	12	5	7	Wilmington, . .	4	-	4
Marshfield, . .	2	-	2	Winchester, . .	5	-	5
Medford, . . .	5	2	3	Winthrop, . .	7	-	7
Medway, . . .	4	-	4				
Melrose, . . .	5	-	5	Total, . . .	303	77	226
Milford, . . .	2	-	2				

Widal Test, according to Stage of Disease, April 1, 1903, to March 31, 1904, inclusive.

Approximate Number of Days from Beginning of Disease to Collection of Blood.	Number of Cases.		Approximate Number of Days from Beginning of Disease to Collection of Blood.	Number of Cases.	
	Positive.	Negative.		Positive.	Negative.
1, ...	-	1	17, ...	1	7
2, ...	-	4	18, ...	-	5
3, ...	-	3	20, ...	2	6
4, ...	1	7	21, ...	3	9
5, ...	1	8	23, ...	2	3
6, ...	2	12	26, ...	1	3
7.	3	21	28, ...	1	3
8, ...	3	16	30, ...	1	5
9, ...	3	13	35, ...	-	1
10, ...	6	19	42, ...	1	2
11, ...	1	9	76, ...	1	-
12, ...	3	10	80, ...	1	-
13, ...	2	4	Unknown, ...	18	24
14, ...	19	21			
15, ...	-	1	Total, ...	77	226
16, ...	1	9			

MALARIA.

The number of blood films received by the laboratory during the current year for microscopic diagnosis was considerably lower than that of the year preceding. Of 32 preparations received only 4, or 12.5 per cent., showed the malaria parasite.

This is evidence of a continued reduction in the number of cases and of the reduced prevalence of the disease throughout the State.

Malaria, April 1, 1903, to March 31, 1904.

City or Town.	Number of Cases.	Positive.	Negative.
Acton,	1	-	1
Boston,	4	1	3
Cambridge,	2	-	2
Clinton,	1	-	1
Concord,	1	-	1
Dedham,	1	-	1
Foxborough,	1	-	1
Hyde Park,	1	-	1
Lexington,	1	-	1
Melrose,	1	-	1
Milton,	2	-	2
Norwell,	1	-	1
Quincy,	5	2	3
Tewksbury,	1	1	.
Uxbridge,	1	-	1
Westford,	2	-	2
Winchester,	6	-	6
Total,	32	4	28

STATISTICAL SUMMARIES

OF

DISEASE AND MORTALITY.

STATISTICAL SUMMARIES OF DISEASE AND MORTALITY.

The statistical information relating to disease and mortality which has been received by the Board during each year, either through the medium of voluntary returns or in consequence of legal requirements, has, in the recent reports of the Board, been presented under four different heads or groups. In the reports of 1902 and 1903 this series of statistics has been condensed as much as can be done consistently with a clear and intelligent method of presentation.

These summaries are defined as follows: —

I. *The Weekly Mortality Returns.* — These consist of the reports of deaths, which are made up weekly and are sent to the office of the State Board by the registration officials of cities and towns. They are voluntary, and serve principally to show the seasonal prevalence of each of the chief infectious diseases, and the mortality of children under five years old in weekly periods. This series of statistics has been continued by the Board for more than twenty-five years, and has been published as a summary for twenty years.

II. *The Reports of Certain Infectious Diseases, — Diphtheria and Croup, Scarlet Fever, Typhoid Fever and Measles.* — These are obtained from the annual reports of local boards of health for the year 1903, which are forwarded to the State Board from cities and towns. By comparing the numbers of reported cases with the reported deaths, the mean fatality of each disease in the places from which the reports are made is obtained with a reasonable degree of accuracy. This summary was first presented in the report of 1891, page 878.

III. *Reports of Cities and Towns, made under the Provisions of Chapter 75, Section 52, of the Revised Laws.* — By this act each local board of health is required to report to the State Board every case of "disease dangerous to the public health" which is reported to the local board. A digest of these reports is presented in Summary No. III. This summary was first published in the report of 1893, page 639.

IV. *Annual Reports made under the Provisions of Chapter 75, Section 12, of the Revised Laws.* — The full reports of deaths occurring in each city and town having over 5,000 inhabitants comprise another series of returns, which are summarized in No. IV. The population of these cities

and towns in 1903 constituted about 85 per cent. of the estimated total population of the State. These reports are made under the requirements of the following statute: —

In each city and town having a population of more than five thousand inhabitants, as determined by the last census, at least one member of said board shall be a physician, and the board shall send an annual report of the deaths in such town to the State Board of Health. The form of such reports shall be prescribed and furnished by the State Board of Health. (Revised Laws, chapter 75, section 12.)

This summary was first presented in the report of 1894.

NOTE. — A supply of the postal cards, necessary for the reporting of voluntary mortality returns such as are required for the data presented in section I. of the following summary, will be forwarded to the registration officers of any city or town who are willing to contribute the necessary information.

Postal cards are also sent to all boards of health in the State, for the purpose of aiding them to comply with the provisions of chapter 75, section 52, of the Revised Laws, relative to the reporting of diseases dangerous to the public health to the State Board immediately after reports of the same are received by the local board.

Annual blank forms are also sent to each local board of health in cities and towns having over 5,000 inhabitants, for the return of such information as is called for by the provisions of chapter 75, section 12, of the Revised Laws.

I.

The Weekly Mortality Returns.

In the following summary, the voluntary reports of deaths received at the close of each week from the city registrars, town clerks and boards of health of the cities and towns are epitomized for the year 1903. The chief value of this abstract consists in the fact that it presents a continuous history of the mortality from certain specified diseases from week to week throughout the year.

This weekly report has been published in the Boston Medical and Surgical Journal every week for a period of twenty-five years or more, and also as a publication of the Board, in a weekly bulletin, since and including 1883.

These returns are necessarily incomplete, since they are voluntary and consequently embrace the statistics of a portion only of the population, the reporting places being chiefly the cities and large towns.

The estimated population of the cities and towns contributing to these returns in 1903 was 2,080,590, or 69 per cent. of the estimated total population.

The following items are embraced in this summary: —

Average height of barometer for each week.
Mean maximum temperature.
Mean minimum temperature.
Rainfall, expressed in inches.
Total deaths reported for each week.
Deaths of children under five years.
Deaths from consumption.
Deaths from acute lung diseases.
Deaths from typhoid fever.
Deaths from diarrhœal diseases.
Deaths from scarlet fever.
Deaths from measles.
Deaths from diphtheria and croup.
Deaths from puerperal fever.
Deaths from whooping-cough.
Deaths from malarial fever.
Deaths from erysipelas.
Deaths from cerebro-spinal meningitis.

The following table contains a summary of the statistics compiled from these weekly returns of mortality: —

Summary for 1903.

1903.	Barometer.	Maximum Mean Thermometer for Each Week.	Minimum Mean Thermometer for Each Week.	Humidity.	Rainfall, in Inches.*	Total Deaths.	Deaths under Five Years of Age.	Consumption.	Acute Lung Diseases.	Typhoid Fever.	Diphtheria and Croup.	Scarlet Fever.	Measles.	Diarrhœal Diseases.	Whooping-cough.	Puerperal Fever.	Malarial Fever.	Erysipelas.	Cerebro-spinal Meningitis.
Jan. 3,	30.06	41	27	69		675	188	56	121	7	15	8	1	7	11	1	-	-	4
10,	29.61	34	22	68		700	211	54	130	6	17	15	2	9	10	-	-	8	4
17,	29.85	36	21	66		696	227	56	117	11	9	6	2	11	11	1	-	-	5
24,	30.16	32	13	64		719	195	64	156	7	10	8	2	18	12	1	-	-	8
31,	30.03	37	25	82	3.40	809	260	69	162	5	10	13	2	18	9	2	-	8	4
Feb. 7,	29.88	39	28	70		801	259	65	167	7	19	8	4	11	6	-	-	2	4
14,	29.91	44	29	65		762	225	56	186	1	18	6	4	12	20	1	-	1	4
21,	29.98	26	12	72		724	217	58	147	6	21	6	1	12	13	-	-	2	4
28,	30.16	45	29	66	3.89	744	216	65	159	5	8	13	4	12	7	-	-	-	9
March 7,	30.37	45	31	74		751	231	62	164	2	12	4	3	8	23	-	-	2	5
14,	30.29	54	38	88		817	225	73	149	6	14	13	1	10	11	1	-	1	9
21,	30.31	58	38	84		752	205	68	141	4	14	8	4	8	10	1	-	1	4
28,	30.03	54	39	78	6.14	627	162	66	120	4	7	7	4	6	9	-	-	8	6
April 4,	29.93	54	36	76		711	216	63	118	5	18	5	6	8	23	-	-	2	10
11,	30.07	52	38	66		662	178	67	94	7	12	7	5	16	7	2	-	4	6
18,	29.78	48	38	78		623	177	58	106	4	11	12	6	11	13	-	-	4	7
25,	29.82	57	41	48	.34	763	211	71	114	5	8	10	8	15	11	1	-	-	8
May 2,	30.14	63	44	57		699	188	66	100	8	5	15	8	16	8	1	-	4	7
9,	30.18	55	45	82		676	181	74	118	8	11	17	2	14	10	-	1	1	8
16,	30.21	69	48	66		649	189	61	93	5	14	13	2	22	12	1	-	2	6
23,	29.95	82	58	54		654	176	70	84	5	9	15	2	15	8	-	-	-	6
30,	30.20	69	51	61	0.82	541	143	59	69	6	12	14	2	16	5	-	-	1	2
June 6,	30.26	71	51	55		539	142	56	62	8	11	17	6	17	6	1	-	8	6
13,	29.94	69	58	93		553	183	62	64	2	11	6	3	12	2	-	-	1	5
20,	29.87	61	51	84		520	170	54	46	5	8	14	6	12	7	1	-	1	8
27,	29.95	62	51	86	.44	543	166	54	41	9	5	13	4	36	5	-	-	8	6
July 4,	29.89	77	62	66		558	179	50	44	4	11	9	2	39	12	1	-	2	4
11,	29.93	87	67	65		675	254	61	51	5	5	7		80	6	1	-	-	7
18,	29.83	79	62	63		737	321	50	53	2	12	11		150	2	-	-	2	2
25,	29.91	72	60	82	3.13	622	242	61	84	5	18	5	2	122	4	-	-	-	5
Aug. 1,	29.96	78	62	68		680	355	56	40	8	13	9	2	175	10	1	-	-	5
8,	30.11	68	56	81		696	336	39	30	8	8			168	2	1	-	2	12
15,	29.99	74	58	71		656	282	47	21	8	9	2		184	4	-	-	8	4
22,	29.93	77	62	77		674	291	45	27	9	16	4		150	8	-	-	-	4
29,	30.00	68	59	78	4.21	639	266	52	31	8	9	6		186	4	-	-	-	6

Sept. 5,	30.06	72	58	92	-	597	234	54	30	12	5	5	-	107	7	-	-	-	6
12,	30.21	71	56	68	-	669	265	58	29	11	6	3	-	113	3	-	-	-	8
19,	30.12	80	64	72	-	636	248	54	40	21	10	1	-	107	2	-	-	-	2
26,	30.09	69	51	66	1.84	561	241	55	35	8	9	2	1	87	3	1	-	2	8
Oct. 3,	30.17	66	50	73	-	554	201	44	31	14	12	4	-	71	2	1	-	-	8
10,	30.13	64	55	87	-	619	215	70	47	8	12	4	-	63	7	-	-	-	8
17,	29.94	61	49	82	-	531	180	46	42	9	17	3	1	38	2	-	-	3	2
24,	29.98	61	43	67	-	565	185	67	30	8	15	1	1	23	2	-	-	-	3
31,	30.00	54	37	55	4.18	555	171	49	63	12	21	3	-	29	3	1	-	1	4
Nov. 7,	29.93	59	42	67	-	539	138	61	64	20	15	3	4	22	2	1	-	1	3
14,	30.03	57	41	57	-	573	144	53	82	10	13	2	3	15	2	1	-	3	5
21,	30.23	42	30	69	-	494	132	36	64	10	21	2	3	17	1	-	-	2	2
28,	29.94	35	23	63	2.26	586	160	63	88	10	18	8	1	14	2	2	-	1	4
Dec. 5,	30.03	35	24	78	-	608	133	45	90	13	18	-	3	12	4	-	-	2	2
12,	29.91	44	29	72	-	635	154	78	105	10	18	7	4	12	2	-	-	1	2
19,	30.15	31	16	56	-	589	152	49	103	9	10	6	4	6	4	1	-	1	2
26,	29.74	43	25	73	3.21	651	158	65	103	10	8	7	2	15	4	-	-	1	1
Totals,	-	-	-	-	43.86	33,509	10.718	3,034	4,355	385	623	388	129	2,240	368	27	1	71	249
Weekly average,	-	-	-	-	-	644	206	58	84	7.4	12.0	7.5	2.5	43.1	7.1	.5	.02	1.4	4.8
Rate per 1,000 deaths,	-	-	-	-	-	-	319.8	90.5	129.9	11.5	18.6	11.6	3.8	66.8	11.0	.80	.03	2.12	7.43
Rate per 1,000 population,	-	-	-	-	-	16.10	5.15	1.46	2.09	.18	.30	.18	.06	1.08	.18	.01	.0005	.034	.12

Average reporting population, ... 2,080,590

* Rainfall in inches. The figures in this column are given by months instead of by weeks.

Condensed Statistics, embracing the Total Deaths, Deaths under Five Years, and Deaths from Certain Causes in Reporting Cities and Towns of Massachusetts in 1903.

	Deaths.	Average Number of Deaths in Each Week.	Percentage of Total Mortality.	Death-rate per 1,000 of Reporting Population.
Total deaths,	33,509	644	100.00	16.1
Deaths under five years,	10,718	206	31.98	5.1
Deaths from consumption,	3,034	58	9.05	1.5
Deaths from acute lung diseases,	4,355	84	13.00	2.1
Deaths from diarrhœal diseases,	2,240	43	6.68	1.1
Deaths from typhoid fever,	385	7.4	1.15	.18
Deaths from diphtheria and croup,	623	12	1.86	.30
Deaths from scarlet fever,	388	7.5	1.16	.18
Deaths from measles,	129	2.5	.38	.06
Deaths from cerebro-spinal meningitis,	249	4.8	.74	.12
Deaths from whooping-cough,	368	7.1	1.10	.18
Deaths from puerperal fever,	27	.5	.08	.01
Deaths from erysipelas,	71	1.4	.21	.03
Deaths from malarial fever,	1	.02	.003	.0005

The usual observations upon the weekly mortality statistics are omitted, and the foregoing short table, containing the essential statistics, supplies their place. The omission is made because information of the same character is presented in a different form in Section IV. of these summaries. The chief difference consists in the fact that the information given in this section (I.) is entirely voluntary and is detailed by weeks, while that of Section IV. is required by statute, the data not being forwarded to the Board until after the close of the year. The population which furnishes the statistics presented in Section IV. is considerably larger than that embraced in Section I., but both populations consist of the more densely settled parts of the State.

METEOROLOGY.

The principal points of sanitary interest in the meteorology of Massachusetts for the year 1903 were the following: —

The mean temperature of the year in the State was 47.9° F.

The mean temperature of the summer months of June, July, August and September was as follows: June, 59.6°; July, 69.6°; August, 63°; September, 62.3°.

The annual rainfall was 43.6 inches, or a little below the average of a series of years.

Diphtheria and Croup.

[Antitoxin Period.]

	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	Total 1895-1903.
Reported cases, .	7,856	8,915	7,856	3,843	6,540	12,578	8,921	5,848	5,319	67,626
Deaths, . . .	1,484	1,348	1,107	507	758	1,274	938	666	592	8,674
Fatality (per cent.),	18.9	15.1	14.1	13.2	11.6	10.2	10.5	11.4	11.1	12.9

Scarlet Fever.

	1902.	1903.	Total 1891-1903.
Reported cases, ...	4,306	4,911	68,489
Deaths, ...	251	387	3,941
Fatality (per cent.), ...	5.8	7.8	5.7

Typhoid Fever.

Reported cases, ...	2,542	2,594	32,172
Deaths, ...	383	363	5,751
Fatality (per cent.), ...	15.1	14.0	17.9

Measles.

Reported cases, ...	11,949	8,166	98,007
Deaths, ...	162	149	1,273
Fatality (per cent.), ...	1.4	1.8	1.3

In the foregoing tables the statistics relating to diphtheria and croup have been arranged in two periods, which may properly be called the pre-antitoxin and the antitoxin periods, since antitoxin came into general use in the State about the beginning of the year 1895. The mean fatality in the former period (1891–94) was 28.3 per cent. (ratio of deaths to cases), and in the latter period (1895–1903) it was 12.9 per cent., or less than half as large.

In England, where systematic records have been kept in regard to the fatality of these diseases, the percentage of deaths to cases in diphtheria, as determined from 342,312 cases and 64,900 deaths which occurred in the period of twelve years (1890–1903) was 18.9. There was, however, a uniform diminution in this percentage, after the introduction of antitoxin treatment, from 25.1 in 1894 to 13.6 in 1903.

The fatality of scarlet fever showed quite similar figures to those of Massachusetts, the maximum in England being 8 per cent. in 1890 and the minimum 3.1 per cent. in 1899.

In typhoid fever the fatality varied also from 20.8 in 1891 to 15.1 in 1902.

The fatality of measles in Massachusetts varied from a maximum of 4 per cent. in 1892 to a minimum of 0.7 in 1897.

III.

Official Returns of Notified Diseases Dangerous to the Public Health, 1903.

The figures presented in the following summary are those of the official returns of diseases "dangerous to the public health," made to the State Board of Health during the year 1903, under the provisions of chapter 75 of the Revised Laws. In this act no disease is specified as being "dangerous to the public health" except smallpox. Hence the State Board deemed it necessary to indicate the diseases which should be included in the meaning of the term "dangerous to the public health." They are the following: smallpox, scarlet fever, measles, typhoid fever, diphtheria, membranous croup, cholera, yellow fever, typhus fever, cerebro-spinal meningitis, hydrophobia, malignant pustule, leprosy and trichinosis.

The whole number of cases of infectious diseases reported to the Board in 1903, under the provisions of this act, was 25,572, which were divided as follows: —

Reported cases of smallpox,	422
Reported cases of scarlet fever,	5,877
Reported cases of diphtheria and croup,	6,888
Reported cases of typhoid fever,	2,955
Reported cases of measles,	9,430
Total,	25,572

The summary for the ten years 1893–1903 is as follows: —

	Reported Cases of					Total.
	Smallpox.	Diphtheria and Croup.	Scarlet Fever.	Typhoid Fever.	Measles.	
1893 (four months only),	35	1,109	2,914	1,525	1,503	7,086
1894,	181	4,178	6,731	2,372	2,133	15,595
1895,	1	7,806	6,194	2,438	4,868	21,307
1896,	5	8,515	3,801	2,637	6,362	21,320
1897,	18	7,613	5,495	2,104	12,695	27,925
1898,	10	3,980	3,667	2,196	4,478	14,331
1899,	105	7,134	5,349	2,776	12,355	27,719
1900,	104	12,641	6,396	2,967	10,507	32,615
1901,	773	9,793	4,356	2,689	9,398	27,009
1902,	2,314	7,036	4,613	2,721	17,249	33,933
1903,	422	6,888	5,877	2,955	9,430	25,572
Total,	3,968	76,693	55,393	27,380	90,978	254,412

By months these diseases were reported as follows: —

Cases of Infectious Diseases reported to the State Board of Health by Mon
1903.

Months.	Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.	Glanders.	Months.	Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.
January, .	109	642	642	194	1,277	-	August, .	22	274	407	435	1
February, .	59	556	551	136	1,310	-	September, .	14	239	443	389	
March, .	45	612	464	132	1,411	-	October, .	8	360	955	438	2
April, .	50	537	387	107	1,159	-	November, .	10	403	866	334	5
May, . .	33	671	500	171	1,173	1	December, .	9	623	838	206	8
June, . .	23	616	453	191	903	-	Total, .	422	5,877	6,888	2,955	9,4
July, . .	40	344	392	222	346	-						

The following table is introduced for the purpose of facilitating the parison of the seasonal prevalence of the diseases named in the tab different years. By means of the method employed the errors due t difference in the length of the months are eliminated. The figures sl be read as follows: For example, the mean daily number of reported of diphtheria reported throughout the year in 1903 was 18.9, of sc fever, 16.1, of typhoid fever, 8.1, and of measles, 25.8. During the m of January the mean daily number of reported cases of these diseases for diphtheria 20.7, scarlet fever, 20.7, typhoid fever, 6.3, and for mea 41.2 (see columns marked A).

Assuming a standard of 10 as a daily mean throughout the year for disease, the ratios for January were as follows: diphtheria, 11.0, sc fever, 12.9, typhoid fever, 7.8, and measles, 15.9 (see columns marke So that, for each 10 cases of diphtheria reported as a daily mean thro out the year 1903 there were 11.0 in January, 10.4 in February, 7 March, etc.

From this table it appears that the maximum prevalence of diphthe 1903 was in October and the minimum in July. The prevalence in last three months of the year was greater than that of the first three mo There has been in every one of the past nine years a decline in the alence of the disease in December, except in December, 1899.

The prevalence of scarlet fever was above the mean in January, ruary, March, April, May, June and December, and below it in the rem ing months, the maximum occurring in May and the minimum in Septen In the previous year the maximum was in November and the minimu August.

Typhoid fever was, as usual, below the mean in the intensity of its p

lence in the first seven months of 1903, rising to a maximum in October. In 1903, as in 1901 and 1902, the intensity of its prevalence in September and October was nearly equal.

The prevalence of measles was much above the mean in the first half of the year and below it in the last half, the maximum occurring in February and the minimum in September.

Certain Infectious Diseases. Seasonal Intensity of Prevalence.

MONTHS.	DIPHTHERIA.			SCARLET FEVER.			TYPHOID FEVER.			MEASLES.		
	1903.		1902.	1903.		1902.	1903.		1902.	1903.		1902.
	A	B	B	A	B	B	A	B	B	A	B	B
	Mean Daily Number of Cases reported in Each Month.	Decimal Ratio.	Decimal Ratio.	Mean Daily Number of Cases reported in Each Month.	Decimal Ratio.	Decimal Ratio.	Mean Daily Number of Cases reported in Each Month.	Decimal Ratio.	Decimal Ratio.	Mean Daily Number of Cases reported in Each Month.	Decimal Ratio.	Decimal Ratio.
January, .	20.7	11.0	13.2	20.7	12.9	9.8	6.3	7.8	6.6	41.2	15.9	12.0
February, .	19.7	10.4	12.3	19.8	12.3	11.0	4.8	5.9	7.0	46.8	18.1	17.5
March, .	15.0	7.9	10.3	19.7	12.2	9.1	4.3	5.3	5.5	45.5	17.6	19.9
April, .	12.9	6.8	9.4	17.9	11.1	10.2	3.6	4.4	5.0	38.6	14.9	17.1
May, . .	16.1	8.5	9.8	21.6	13.4	11.2	5.5	6.8	6.3	37.8	14.6	19.7
June, .	15.1	8.0	8.4	20.5	12.7	9.4	6.4	7.5	5.5	30.1	11.6	12.4
July, . .	12.6	6.7	6.0	11.1	6.9	6.6	7.2	8.9	5.9	11.2	4.3	4.7
August, .	13.1	6.9	6.2	8.8	5.5	6.3	14.3	17.7	9.1	4.9	1.9	1.6
September,	14.4	7.6	8.5	8.0	5.0	7.4	13.0	16.1	20.2	2.3	0.9	1.0
October, .	30.8	16.3	12.0	11.6	7.2	10.1	14.1	17.4	20.4	8.4	3.2	1.7
November,	28.9	15.3	13.0	13.4	8.3	14.7	11.1	13.7	15.4	18.4	7.1	4.7
December,	27.0	14.3	11.1	20.1	12.5	14.4	6.6	8.2	13.1	26.0	10.1	8.2
Mean, .	18.9	10.0	10.0	16.1	10.0	10.0	8.1	10.0	10.0	25.8	10.0	10.0

Cases of Infectious Diseases reported to the State Board of Health from Two Hundred and Seventy-three Cities and Towns during 1903.

	Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.		Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.
Abington, . .	-	5	7	-	1	Amesbury, . .	2	11	1	10	-
Acton, . . .	-	6	3	3	51	Amherst, . .	-	25	4	3	-
Acushnet, . .	-	6	2	-	-	Andover, . .	-	14	19	7	-
Adams, . . .	6	36	16	11	-	Arlington, . .	-	47	35	4	23
Agawam, . .	7	1	4	-	-	Ashburnham, . .	-	1	-	-	-

Cases of Infectious Diseases reported to the State Board of Health from Two Hundred and Seventy-three Cities and Towns during 1903 — Continued.

	Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.		Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.
Ashfield,	-	1	-	1	-	Chatham,	-	-	3	-	-
Ashland,	-	-	3	-	-	Chelmsford,	-	1	9	8	12
Athol,	-	2	6	2	3	CHELSEA,	2	39	55	28	12
Attleborough,	1	9	3	8	17	Cheshire,	-	3	-	-	6
Auburn,	-	-	1	1	10	Chester,	-	-	-	5	-
Avon,	-	1	3	-	13	Chicopee,	-	160	27	18	158
Ayer,	2	2	1	-	7	Clinton,	-	29	10	7	46
Barnstable,	16	1	3	4	10	Cohasset,	-	6	3	-	5
Barre,	-	4	-	-	2	Colrain,	-	-	1	-	-
Becket,	1	-	4	-	-	Concord,	-	3	-	3	3
Bedford,	-	8	1	1	41	Conway,	4	2	-	-	-
Belchertown,	-	-	-	1	-	Cottage City,	-	-	1	4	8
Bellingham,	-	-	2	4	2	Dalton,	-	-	4	-	-
Belmont,	-	10	7	-	1	Dana,	-	-	-	-	1
Berlin,	-	4	2	-	-	Danvers,	-	11	3	2	1
Bernardston,	1	-	-	-	-	Dartmouth,	-	12	3	-	-
BEVERLY,	-	20	16	25	223	Dedham,	5	74	27	3	9
Billerica,	-	-	2	-	-	Deerfield,	-	3	-	-	-
Bolton,	-	2	-	-	10	Dighton,	-	14	5	1	-
BOSTON,	71	1,495	2,077	907	2,133	Douglas,	-	5	1	-	3
Bourne,	-	-	8	-	-	Dracut,	-	-	2	-	-
Boylston,	-	2	-	-	-	Dudley,	-	4	1	-	-
Braintree,	-	20	32	8	7	Dunstable,	-	5	-	-	1
Bridgewater,	-	3	-	5	-	Duxbury,	-	-	2	3	2
BROCKTON,	1	63	51	41	6	East Bridgewater,	-	1	2	1	-
Brookfield,	-	5	-	-	30	Easthampton,	-	-	1	-	-
Brookline,	-	52	56	10	84	East Longmeadow,	-	2	-	-	7
Buckland,	-	-	10	-	-	Easton,	-	27	6	-	1
Burlington,	-	1	-	-	-	Essex,	-	-	5	-	3
CAMBRIDGE,	6	187	327	125	77	EVERETT,	-	46	81	17	15
Canton,	-	7	40	-	74	Fairhaven,	-	18	4	5	13
Carlisle,	-	4	-	1	-	FALL RIVER,	118	249	137	161	-
Carver,	-	-	2	-	-	Falmouth,	-	3	-	-	24
Charlemont,	-	-	1	-	-	FITCHBURG,	2	37	14	25	488
Charlton,	-	1	-	-	-	Foxborough,	11	1	2	4	-

Cases of Infectious Diseases reported to the State Board of Health from Two Hundred and Seventy-three Cities and Towns during 1903 — Continued.

	Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.		Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.
Framingham,	-	1	28	12	36	Kingston,	-	3	1	7	1
Franklin,	-	5	3	3	-	Lancaster,	2	5	3	-	30
Freetown,	-	3	-	1	18	LAWRENCE,	5	54	210	149	627
Gardner,	-	8	17	-	-	Lee,	-	-	-	7	-
Georgetown,	-	-	3	-	1	Leicester,	-	3	-	-	-
Gill,	1	18	1	-	-	Lenox,	-	12	1	1	-
GLOUCESTER,	-	20	365	9	2	Leominster,	10	21	5	4	172
Granville,	-	1	6	-	10	Lexington,	-	21	1	3	34
Great Barrington,	-	11	2	1	-	Leyden,	-	-	1	-	-
Greenfield,	-	4	5	4	6	Littleton,	-	1	1	2	1
Greenwich,	-	-	-	-	1	LOWELL,	11	138	266	238	56
Groton,	-	-	1	1	-	Ludlow,	-	7	12	-	-
Groveland,	-	-	4	3	-	Lunenberg,	-	2	-	-	1
Hadley,	-	-	1	-	-	LYNN,	10	51	261	47	18
Hampden,	-	1	1	-	52	MALDEN,	-	106	167	68	191
Hanover,	-	-	1	-	-	Manchester,	-	3	1	-	1
Hanson,	-	1	-	1	-	Mansfield,	2	17	-	2	2
Hardwick,	-	4	3	4	15	Marblehead,	1	3	51	4	24
Harvard,	-	4	-	-	-	MARLBOROUGH,	1	49	98	9	306
Harwich,	-	1	-	-	-	Marshfield,	-	-	28	-	-
Hatfield,	-	-	1	-	-	Mattapoisett,	-	-	2	-	2
HAVERHILL,	9	24	58	56	14	Maynard,	-	34	7	15	8
Hingham,	-	1	-	-	-	Medfield,	-	3	-	-	-
Hinsdale,	-	-	2	-	44	MEDFORD,	-	10	38	17	34
Holbrook,	-	-	7	-	8	Medway,	-	5	10	3	-
Holden,	-	1	1	4	-	MELROSE,	1	16	20	3	23
Holliston,	-	6	6	-	-	Mendon,	-	1	3	-	-
HOLYOKE,	10	43	75	22	485	Merrimac,	-	2	-	-	-
Hopedale,	-	5	6	-	-	Methuen,	2	4	14	11	9
Hopkinton,	-	1	-	-	-	Middleborough,	-	15	2	4	-
Hudson,	1	72	7	6	60	Middleton,	-	-	-	-	2
Hull,	-	-	-	2	1	Milford,	-	21	67	4	5
Huntington,	-	-	2	1	-	Millbury,	-	5	7	3	32
Hyde Park,	-	94	5	3	1	Milton,	-	34	21	12	6
Ipswich,	4	1	11	18	52	Monson,	-	14	3	2	65

Cases of Infectious Diseases reported to the State Board of Health from Two Hundred and Seventy-three Cities and Towns during 1903 — Continued.

	Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.		Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.
Montague,	1	-	2	1	-	QUINCY,	-	26	60	23	124
Nantucket,	1	-	-	-	-	Randolph,	-	1	5	2	2
Natick,	4	2	14	-	1	Raynham,	-	5	1	-	-
Needham,	-	16	-	1	1	Reading,	-	6	3	6	2
NEW BEDFORD,	8	545	123	106	383	Rehoboth,	-	3	-	-	-
Newbury,	-	-	1	-	-	Revere,	-	21	44	-	-
NEWBURYPORT,	-	4	31	19	6	Rochester,	-	-	1	-	-
NEWTON,	1	77	67	28	312	Rockland,	-	5	13	5	6
NORTH ADAMS,	1	75	59	54	1	Rockport,	1	2	85	-	7
NORTHAMPTON,	1	19	39	13	48	Rowley,	-	4	-	1	1
North Andover,	-	-	10	4	26	Rutland,	-	8	-	-	-
N. Attleborough,	-	-	6	-	28	SALEM,	1	31	165	59	143
Northborough,	-	2	3	4	2	Salisbury,	-	-	3	-	-
Northbridge,	1	18	21	3	9	Sandisfield,	-	-	-	-	3
North Brookfield,	-	2	10	1	8	Saugus,	-	3	7	-	19
Northfield,	-	-	1	-	7	Scituate,	1	-	-	-	-
North Reading,	-	1	1	-	-	Seekonk,	-	3	4	-	-
Norton,	-	6	1	1	4	Sharon,	-	-	2	1	40
Norwell,	-	-	6	-	-	Sheffield,	-	19	-	-	7
Norwood,	-	13	39	2	1	Shelburn,	-	-	6	-	-
Oakham,	-	5	-	-	13	Sherborn,	-	-	20	-	1
Orange,	-	1	3	-	-	Shirley,	14	-	-	-	34
Orleans,	-	1	3	-	-	Shrewsbury,	-	6	-	1	14
Oxford,	-	1	-	-	3	Somerset,	-	5	2	-	-
Palmer,	-	31	14	5	8	SOMERVILLE,	-	139	194	27	24
Peabody,	-	8	16	3	-	Southborough,	-	-	1	-	-
Pelham,	-	-	2	-	1	Southbridge,	1	4	1	-	2
Pembroke,	-	-	-	-	1	South Hadley,	-	1	1	3	7
Pepperell,	21	2	-	1	4	Southwick,	-	1	-	-	-
Petersham,	-	2	-	-	1	Spencer,	-	15	6	4	6
PITTSFIELD,	-	9	14	5	166	SPRINGFIELD,	3	124	105	92	654
Plymouth,	-	53	6	10	10	Sterling,	-	-	1	-	-
Plympton,	-	-	-	2	-	Stockbridge,	-	-	1	-	-
Princeton,	-	-	-	-	4	Stoneham,	-	2	6	4	7
Provincetown,	-	-	2	-	-	Stoughton,	-	2	28	1	64

Cases of Infectious Diseases reported to the State Board of Health from Two Hundred and Seventy-three Cities and Towns during 1903 — Concluded.

	Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.		Smallpox.	Scarlet Fever.	Diphtheria.	Typhoid Fever.	Measles.
Stow,	-	3	7	-	3	West Boylston,	-	-	-	-	8
Sudbury,	-	1	-	-	-	West Brookfield,	-	2	-	-	24
Sutton,	-	3	2	-	3	Westfield,	1	31	59	13	15
Swampscott,	-	13	10	-	1	Westford,	5	3	1	-	36
Swansea,	-	4	3	-	-	Westhampton,	-	1	-	-	-
TAUNTON,	12	26	66	6	20	Westminster,	-	2	-	-	68
Templeton,	-	-	3	1	-	West Newbury,	-	1	-	-	-
Tewksbury,	-	2	1	2	-	Weston,	-	1	2	3	-
Tisbury,	1	3	-	-	10	Westport,	-	-	-	3	26
Tolland,	-	5	-	-	-	West Springfield,	3	19	9	1	7
Topsfield,	-	1	-	-	-	West Stockbridge,	-	22	1	1	-
Townsend,	-	-	4	1	6	Westwood,	-	4	1	1	-
Tyringham,	-	5	-	-	-	Weymouth,	-	14	55	2	6
Upton,	-	1	2	1	2	Whitman,	2	3	2	-	1
Uxbridge,	1	21	13	11	14	Wilbraham,	-	3	3	-	1
Wakefield,	-	13	11	3	3	Williamsburg,	-	4	1	1	-
Walpole,	-	-	6	-	1	Williamstown,	-	4	2	14	8
WALTHAM,	-	31	33	42	62	Wilmington,	-	3	-	-	-
Ware,	-	42	2	-	2	Winchendon,	-	6	1	5	23
Wareham,	2	3	2	-	-	Winchester,	-	23	15	7	162
Warren,	-	2	7	1	-	Winthrop,	3	6	16	9	1
Watertown,	-	22	8	4	13	WOBURN,	-	135	17	7	3
Wayland,	1	33	1	-	5	WORCESTER,	3	167	167	78	385
Webster,	2	10	9	-	-	Worthington,	-	-	1	-	18
Wellesley,	-	10	-	2	17	Wrentham,	-	1	-	-	-
Wenham,	-	1	-	-	-	Yarmouth,	-	3	-	-	-
Westborough,	-	39	5	2	160	Total,	422	5,877	6,888	2,955	9,430

Glanders occurred in the following places: —

Chelsea,	1
Methuen,	1
	2

List of Cities and Towns from which no Reports were received.

I. Cities.

None.

II. Towns having a Population of More than 5,000.

Blackstone. — 1.

III. Towns having a Population of More than 1,000 but Less than 5,000 in Each

Dennis,
Grafton,
Hamilton,
Hubbardston,
Millis,
Nahant,
New Marlborough,
West Bridgewater. — 8.

IV. Towns having Less than 1,000 Inhabitants.

Alford,
Ashby,
Berkley,
Blandford,
Boxborough,
Boxford,
Brewster,
Brimfield,
Chesterfield,
Chilmark,
Clarksburg,
Cummington,
Dover,
Eastham,
Egremont,
Erving,
Florida,
Gay Head,
Goshen,
Gosnold,
Granby,
Halifax,
Hancock,
Hawley,
Heath,
Holland,
Lakeville,
Lanesborough,
Leverett,
Longmeadow,
Lynnfield,
Marion,
Mashpee,
Middlefield,
Monroe,
Monterey,
Montgomery,
Mt. Washington,
New Ashford,
New Braintree,
New Salem,
Norfolk,
Otis,
Paxton,
Peru,
Phillipston,
Plainfield,
Prescott,
Richmond,
Rowe,
Royalston,
Russell,
Savoy,
Shutesbury,
Sunderland,
Truro,
Tyngsborough,
Wales,
Warwick,
Washington,
Wellfleet,
Wendell,
West Tisbury,
Whately,
Windsor. — 65.

The following towns sent notice to the Board that no infectious diseases had been reported within their limits during the year 1903: —

Edgartown,
Enfield,
Lincoln,
Sandwich,
Southampton,
Sturbridge. — 6.

A supply of postal cards for the purpose of reporting infectious diseases to the State Board of Health, as required by statute, will be forwarded to any local board of health on application to the secretary of the State Board, Room 141, State House, Boston.

IV.

Official Returns of Deaths in Cities and Large Towns (Revised Laws, Chapter 75, Section 12).

In the following summary, the statistics of deaths required by chapter 75, section 12, of the Revised Laws, are presented. These statistics are returned to the Board from each city and town which has, "according to the latest census, more than five thousand inhabitants."

The cities and towns which have contributed these returns for the year 1903 comprise nearly the same list as that of 1902. This list embraces all of the 33 cities and the towns having more than 5,000 inhabitants in each, except Adams and Montague.

Reading has also voluntarily contributed returns of deaths to the Board during the past six years, although not required by law to send them. Grafton continued to send returns in 1900, 1901 and 1902, although not so required by law, its population having fallen below 5,000 at the census of 1900.

Montague has failed to send the required returns in nearly every year since the law was enacted.

The list for the year 1903 includes 92 cities and towns. In order to allow for the growth of population, and hence to arrive at a fairly accurate estimate of the death-rates of these cities and towns, an estimate of the population of each city and town in 1903 has been made, this estimate being based upon the rate of growth between the two census years 1895 and 1900.

The total estimated population of this group of cities and towns in 1903 was 2,553,786, or about 85 per cent. of the estimated total population of the State in that year.

The whole number of registered deaths in these towns in 1903 was 41,210, and the death-rate, as calculated from the foregoing estimated population, was 16.14 per 1,000 of the living population, that of the previous year having been 16.21 per 1,000 and that of 1901 16.86 per 1,000.

These were not only the lowest death-rates of this reporting population observed during the ten years since the enactment of the law requiring these returns but were also considerably lower than the mean annual death-rate of the State for the fifty years ended Dec. 31, 1900, which was 19.22 per 1,000.

Sexes. — The number of deaths of males was 21,026, or 51.03 per cent. of the whole number of deaths whose sex was known; and the deaths of females were 20,176, or 48.97 per cent. There were 8 in which the sex was not stated in the returns.

Ages. — The deaths by four groups of ages were as follows: —

Ages.	Deaths. 1903.	Percentages of All Deaths. 1903.	Percentages of All Deaths. 1902.	Ages.	Deaths. 1903.	Percentage All Deat 1903.	1[illegible]
Under 1 year,	8,803	21.38	21.72	20 to 50 years,	10,029	24.36	[illegible]
1 to 20 years,	6,336	15.39	15.68	50 and over,	15,996	38.86	[illegible]

Infant Mortality. — The deaths of infants under one year old were 8, or 21.4 per cent. of the total mortality, as compared with 21.7 per cer 1902; and this was the lowest rate of infant mortality during the p of ten years since the law was enacted requiring these returns; that o five years 1899–1903 respectively constituted 22.8, 23, 21.6, 21.7 and per cent. of the total mortality.

The deaths of children under five years old were 12,231, or 29.7 per of the total mortality, as compared with 31.2 per cent. for the same a 1902.

All of the percentages in the foregoing table were estimated upor number of deaths of those whose ages were stated in the returns. total number of deaths in which the age was not specified was 44, the number as in 1902.

Still-births. — The number of still-births was 2,765, and when comp with the total mortality (still-births included), this was 6.3 per cent. o total deaths and still-births combined. This was also the same percen as in 1902.

Months and Quarters. — The number of deaths in each quarter of year is shown in the following table: —

	Deaths. 1903.	Percentages. 1903.	Percentages. 190[illegible]
First quarter,	11,221	27.23	24.
Second quarter,	9,788	23.75	23.
Third quarter,	10,752	26.09	26.
Fourth quarter,	9,446	22.93	25.
Total,	41,207	100.00	100.

These percentages differ but little from the mean of several years, w usually shows the highest mortality in the third quarter of the year. 1899, 1901 and 1903 the highest mortality was in the first quarter.

During the forty-year period (1856–95) the mortality was gene above the mean in the third quarters of the years and below it in the three quarters.

The intensity of the seasonal death-rate is more accurately shown in the following table, the method employed being explained on page 568 in Section III. of these summaries, relating to disease notification. By this method the errors which are due to differences in the length of the months are eliminated.

	Deaths in Each Month.	Mean Daily Deaths per Month. 1903.	Centesimal Ratio. 1903.	Centesimal Ratio. 1902.		Deaths in Each Month.	Mean Daily Deaths per Month. 1903.	Centesimal Ratio. 1903.	Centesimal Ratio. 1902.
January, . .	3,795	122.4	108.4	95.1	August, . .	3,675	118.6	105.1	105.8
February, . .	3,602	128.6	113.9	106.3	September, .	3,319	110.6	98.0	103.2
March, . .	3,824	123.4	109.3	98.5	October, . .	3,091	99.7	88.3	98.3
April, . . .	3,583	119.4	105.7	99.7	November, .	2,940	98.0	86.8	96.9
May, . . .	3,369	108.7	96.3	98.2	December, .	3,415	110.2	97.6	105.3
June, . . .	2,836	94.5	83.7	89.5	Annual mean,	-	112.9	100.0	100.0
July, . . .	3,758	121.2	107.3	103.0					

The figures in the foregoing table indicate a departure in excess of the mean death-rate in the first four months of the year and in July and August, while that of the remaining months was below the mean.

The mean maximum departure from the death-rate for each month for the period of twenty years, 1856–75, was 32.9 per cent. in August, and the twenty-year period 1876–95 it was 20 per cent. in August, while that of February, 1903, was 13.9 per cent. and those of March and January, 1903, were, respectively, 9.3 and 8.4 per cent.

In the two years having the highest death-rates in Massachusetts in the past half century or more (1849 and 1872) the maximum departures from the yearly means were, respectively, 83.4 per cent. in August, 1849, and 40 per cent. in August, 1872. That of January, 1890, the month in which the epidemic of influenza was at its maximum, was 43.4 per cent. above the mean.

The figures for 1903 when compared with those of earlier years in the past half century show a much greater uniformity in the seasonal mortality, since serious epidemics have not prevailed in the State either in the past year or in any of the years of the past decade. The death-rate of 1903, like that of 1902 and 1901, was remarkably low.

Death-rates of Cities and Large Towns. — In Table II., last column, the death-rates of cities and towns having over 5,000 inhabitants are given. These death-rates are obtained by comparing the deaths in each city and town with the estimated population. They vary from a minimum of 6.6 in Wellesley to 23.7 per 1,000 in New Bedford.

The following cities and towns had death-rates above 19 per 1,000 in 1903: New Bedford, 23.7; Salem, 20.0; Fall River, 19.8; Blackstone, 19.6; Chicopee, 19.2; and Taunton, 19.2.

Of the foregoing, Blackstone, New Bedford, Fall River and Chi also had death-rates above 19 per 1,000 in 1902.

The following cities and towns had death-rates less than 12 per in 1903; Everett, 11.9; Newton, 11.7; Whitman, 11.4; Williams 11.2; Revere, 11.1; Brockton, 11.0+; Northampton, 11.0—; Med 10.8; Bridgewater, 10.8; Orange, 10.7; Easthampton, 10.0+; Win ter, 10.0—; Winthrop, 9.9; and Wellesley, 6.6—; of these, Broc Orange, Northampton, Medford, Whitman, Williamstown, Wincheste Wellesley also had death-rates below 12 per 1,000 in 1902.

The following table presents the mean death-rates of cities of over 2 population for the five census years 1870, 1875, 1880, 1885 and 189 gether with the death-rates for the years 1900 and 1903.

In nearly every one of them there appears to have been decided imp ment.

Death-rates of Certain Cities having a Population of More than 25,000. Death-rates of the Five Census Years 1870, 1875, 1880, 1885, 189 for 1900 and 1903.

	Mean Death-rates, 1870, 1875, 1880, 1885 and 1890.	Death-rate, 1900.	Death-rate, 1903.		Mean Death-rates, 1870, 1875, 1880, 1885 and 1890.	Death-rate, 1900.	ra
Boston,	24.1	20.8	17.6*	Haverhill,	17.8	15.2	
Worcester,	19.7	18.8	15.7*	Salem,	22.1	19.6	
Fall River,	23.4	21.0	19.8	Chelsea,	19.7	19.1	
Lowell,	22.5	19.5	18.6	Malden,	17.0	14.6	
Cambridge,	19.9	16.8	15.2	Newton,	13.1	14.9	
Lynn,	17.8	15.8	14.8	Fitchburg,	17.0	14.9	
Lawrence,	26.5	20.0	17.3	Taunton,	19.5	21.1	
New Bedford,	20.9	20.6	23.7	Gloucester,	21.8	14.6	
Springfield,	19.3	18.4	15.8	North Adams,†	17.7†	14.2	
Somerville,	18.2	15.7	14.0	Quincy,	18.7	14.4	
Holyoke,	23.1	21.5	17.2	Waltham,	15.3	15.6	
Brockton,	16.2	13.8	11.0				

* NOTE.—These figures for Boston, Chelsea, Worcester and Taunton include all deaths. clusion of deaths of non-residents in public and private institutions, they would be reduced to Boston, 14.6 in Chelsea, 14.6 in Worcester and 15.9 in Taunton.

† North Adams for 1880, 1885 and 1890 only.

CAUSES OF DEATH.

In Table III. the mortality of the cities and towns embraced in this mary is presented in absolute figures, classified according to the pri causes of death. The same figures are again presented in relative ter Table IV., for the whole group of cities and towns combined. Tw of figures are given in Table IV., in one of which the mortality from

principal cause of death is compared with the estimated population of the group for 1903, as well as for each of the last five years, and in the other with the total mortality of the group of cities and towns.

By this it appears that the general death-rate from all causes, as shown in the lower line at the left of the table, 161.32 per 10,000 living, or, as usually stated, 16.13 per 1,000, was lower than that of either of the preceding years, and since the population comprised in these returns constitutes over 85 per cent. of that of the whole State, there are indications that the death-rate of the State was less than that of any year in the past century.

The decline in the general death-rate is chiefly due to a decrease in the relative number of deaths from infectious diseases, and especially from those which are usually considered as preventable.

The death-rates from each of the following causes was less than that of 1902: consumption, smallpox, measles, diphtheria, typhoid fever, cerebro-spinal meningitis, erysipelas, cholera infantum, dysentery and other diarrhœal diseases, bronchitis, heart diseases and diseases of the brain and spinal cord. Those of consumption, diphtheria, typhoid fever, cerebro-spinal meningitis, erysipelas, cholera infantum and dysentery were also less than the death-rates from the same causes in any of the last five years.

The following table, first published in the report of 1899, presents the combined death-rate from eight of the principal infectious diseases, and also shows that this combined death-rate in 1903 was less than that of any of the years embraced in this series of reports.

The diseases referred to are consumption, measles, scarlet fever, diphtheria, whooping-cough, typhoid fever, puerperal fever and cholera infantum.

The combined death-rate per 10,000 of the population from these eight causes for the nine years (1895–1903) in the cities and towns included in this report (about five-sixths of the total population of the State) was as follows: —

Combined Death-rate from Eight Principal Infectious Diseases.

Year.	Combined Death rate per 10,000.	Year.	Combined Death-rate per 10,000.
1895,	46.4	1900,	40.7
1896,	46.8	1901,	33.5
1897,	39.7	1902,	30.9
1898,	36.3	1903,	30.7
1899,	35.2		

The seasonal table which appeared in the earlier reports, presenting the deaths by months for each city and town and for the whole State, is omitted

in the present report, since the details presented in this table are r
essential value. Its chief value consisted in the column of total figur
the State, which is retained essentially in the table on page 576.

The table of percentages of total mortality shown in Table IV. act
measure as a check or control in case of erroneous estimates of popul:

The changes in the death-rate from consumption, typhoid feve:
puerperal fever (see child-birth in report of 1896, page 804) were
fully treated in the report of 1896. To these may be added the later
ments on the changes in the death-rate from diphtheria, which app
the figures of the past nine years.

The following preventable causes of death, consumption, measles,
let fever, diphtheria, whooping-cough, typhoid fever, puerperal feve
cholera infantum, together constituted 27.2 per cent. of the total mo
in 1894, but had fallen off to 24.2, 24.2, 21.9, 21.1, 20.4, 22.3, 19.9
and 19.0 in the nine succeeding years; while the principal acute lun
eases, diseases of the heart, brain, kidneys, cancer, suicide and ac
had increased from 35.7 per cent. of the total mortality to 36.9, 36.9,
39.2, 40.2, 38.6, 40.1, 42.7 and 43.0 per cent. in the same years.

These all combined constituted the greater part of the total mortal
each of the nine years 1894–1902, and of the diseases specified in the
entitled the "Balance of Mortality," in the annual report of 1896, pag

TABLE I.

Population of Cities and Large Towns estimated for 1903.

Reporting Cities and Towns.	Estimated Population for 1903.	Reporting Cities and Towns.	Est Pop 1
Amesbury,	9,473	Chicopee,	
Amherst,	5,175	Clinton,	
Andover,	7,215	Concord,	
Arlington,	9,857	Danvers,	
Athol,	7,061	Dedham,	
Attleborough,	13,677	Easthampton,	
Beverly,	15,302	Everett,	
Blackstone,	5,721	Fall River,	1
Boston,	603,163	Fitchburg,	
Braintree,	6,383	Framingham,	
Bridgewater,	6,478	Franklin,	
Brockton,	44,873	Gardner,	
Brookline,	22,608	Gloucester,	
Cambridge,	98,639	Great Barrington,	
Chelsea,	35,876	Greenfield,	

TABLE I. — *Concluded.*

Reporting Cities and Towns.	Estimated Population for 1903.	Reporting Cities and Towns.	Estimated Population for 1903.
HAVERHILL,	38,581	QUINCY,	26,042
Hingham,	5,203	Reading,	5,119
HOLYOKE,	49,286	Revere,	12,722
Hudson,	5,541	Rockland,	5,327
Hyde Park,	14,175	SALEM,	36,876
LAWRENCE,	69,766	Saugus,	5,435
Leominster,	14,806	SOMERVILLE,	68,110
LOWELL,	101,959	Southbridge,	11,268
LYNN,	72,497	Spencer,	7,636
MALDEN,	36,286	SPRINGFIELD,	69,359
Marblehead,	7,582	Stoneham,	6,197
MARLBOROUGH,	13,609	Stoughton,	5,544
MEDFORD,	20,962	TAUNTON,	33,656
MELROSE,	13,600	Wakefield,	9,881
Methuen,	8,604	WALTHAM,	25,198
Middleborough,	7,002	Ware,	8,629
Milford,	13,129	Watertown,	11,077
Milton,	7,214	Webster,	9,407
Natick,	9,893	Wellesley,	5,579
NEW BEDFORD,	67,198	Westborough,	5,499
NEWBURYPORT,	14,478	Westfield,	13,418
NEWTON,	37,794	West Springfield,	7,693
NORTH ADAMS,	27,862	Weymouth,	11,344
NORTHAMPTON,	19,583	Whitman,	6,401
North Attleborough,	7,658	Williamstown,	5,088
Northbridge,	8,086	Winchendon,	5,307
Norwood,	6,023	Winchester,	7,908
Orange,	5,616	Winthrop,	7,177
Palmer,	8,368	WOBURN,	14,300
Peabody,	12,179	WORCESTER,	132,044
PITTSFIELD,	22,589	Total,	2,553,786
Plymouth,	10,730		

The death-rate of Amesbury, Athol, Blackstone, Franklin, Gloucester, Marblehead, Marlborough, Newburyport, Rockland and Stoneham was based on the population of 1900, these towns having slightly decreased in population in the five years which elapsed between the census of 1895 and 1900.

Table II.

Total Deaths, Deaths by Sexes and Age Periods and Still-births in Cities and Towns having over 5,000 Inhabitants in Each with General Death-rates estimated for 1903.

	Total Deaths.	Males.	Females.	Sex Unknown.	Still-births.	Deaths under 1.	1-2.	2-3.	3-4.	4-5.	5-10.	10-15.	15-20.	20-30.	30-40.	40-50.	50-60.	60-70.	70-80.	Over 80.	Age Unknown.	Rate per 1,000.
Amesbury,	147	75	72	-	9	11	1	-	3	1	4	3	3	12	11	7	19	21	26	25	-	15.52
Amherst,	80	36	44	-	3	6	3	-	1	-	1	1	-	8	6	1	14	8	15	16	-	15.46
Andover,	88	36	52	-	5	7	2	1	-	-	1	3	3	6	9	8	8	11	19	10	-	12.20
Arlington,	125	57	67	1	13	11	8	2	2	1	2	2	2	5	11	13	10	23	22	10	1	12.68
Athol,	119	60	59	-	6	18	4	1	-	1	4	1	5	1	9	3	17	21	16	17	1	16.85
Attleborough,	174	86	88	-	7	37	4	5	2	3	8	1	2	18	9	17	14	22	19	13	-	12.72
BEVERLY,	232	110	122	-	15	32	8	5	2	5	5	4	3	10	17	18	21	41	32	29	-	15.16
Blackstone,	112	62	50	-	4	21	1	1	2	1	3	3	1	6	15	10	9	19	12	8	-	19.58
BOSTON,*	10,632	5,440	5,192	-	635	2,173	450	234	135	87	249	129	232	907	1,183	1,134	1,175	1,133	901	510	-	16.15
Braintree,	118	63	55	-	11	11	3	1	2	4	2	1	2	8	14	15	9	18	20	8	-	18.49
Bridgewater,†	70	40	30	-	2	6	3	1	-	-	1	-	-	8	3	8	4	12	17	7	-	10.81
BROCKTON,	495	244	251	-	39	84	16	6	4	4	11	5	11	42	55	37	59	63	49	48	1	11.03
Brookline,	292	151	141	-	12	31	6	10	-	6	3	5	6	17	24	28	22	55	46	33	-	12.91
CAMBRIDGE,	1,501	740	761	-	93	323	72	26	24	10	44	15	27	129	123	115	155	175	168	94	1	15.22
CHELSEA,‡	608	349	259	-	40	128	24	10	8	3	12	10	5	37	49	36	58	98	87	42	1	14.63
CHICOPEE,	404	220	184	-	29	136	29	14	14	13	20	5	10	28	20	16	15	38	32	14	-	19.21
Clinton,	214	118	96	-	21	50	6	9	2	-	4	3	8	19	22	19	19	29	16	8	-	14.12
Concord,	80	40	40	-	4	11	3	2	-	-	1	2	1	9	3	6	10	6	20	6	-	13.47
Danvers,§	109	50	59	-	-	20	4	1	-	-	2	3	2	4	2	15	9	19	10	18	-	12.45
Dedham,	112	48	64	-	9	19	-	2	-	-	3	-	2	6	8	8	12	23	16	13	-	14.73
Easthampton,	61	24	37	-	5	11	4	3	2	-	2	-	1	4	3	2	6	8	6	9	-	10.01
EVERETT,	340	175	165	-	31	87	17	6	5	5	10	3	7	24	18	27	25	46	35	25	-	11.88
FALL RIVER,	2,290	1,160	1,130	-	369	822	-‖	-‖	-‖	-‖	97	-‖	-‖	165	164	132	185	159	80	43	-	19.82

FITCHBURG,	459	226	233	-	27	127	35	12	5	3	17	6	9	40	32	22	38	42	48	23	-	13.09
Framingham,	169	80	89	-	6	24	1	4	1	2	7	3	3	11	11	10	13	34	25	16	4	13.48
Franklin,	78	42	36	-	3	6	1	-	3	-	2	-	4	8	4	10	8	10	13	9	-	15.55
Gardner,	201	117	84	-	18	46	12	9	12	3	8	5	8	12	10	15	14	20	18	9	-	16.85
GLOUCESTER,	425	221	203	1	25	76	21	8	5	11	16	15	13	37	37	28	31	46	51	29	1	16.27
Great Barrington,	108	57	51	-	4	12	2	2	1	-	1	-	2	12	6	6	13	14	20	17	-	16.64
Greenfield,	130	72	56	2	5	20	2	1	-	2	-	2	3	9	11	7	12	24	23	12	2	14.53
HAVERHILL,	570	274	296	-	55	85	17	6	6	7	11	5	14	48	45	46	61	81	84	52	2	14.77
Hingham,	70	34	36	-	1	5	-	-	-	-	-	-	-	6	4	10	4	8	16	17	-	13.45
HOLYOKE,	848	454	394	-	57	313	56	25	13	9	15	12	17	59	79	56	58	66	46	24	-	17.20
Hudson,	78	42	36	-	7	14	4	-	-	2	-	3	2	6	6	4	9	14	9	5	-	14.08
Hyde Park,	201	96	105	-	19	37	7	3	4	5	5	-	4	14	20	16	21	20	32	14	1	14.17
LAWRENCE,	1,204	622	582	-	81	354	68	20	21	7	24	13	23	81	104	93	123	137	93	43	-	17.26
Leominster,	178	93	85	-	10	25	5	5	2	-	4	3	1	13	10	22	16	19	33	20	-	12.02
LOWELL,	1,898	945	953	-	124	554	106	39	30	9	38	37	46	126	160	136	179	183	168	87	-	18.62
LYNN,	1,072	551	521	-	52	191	30	20	10	8	29	17	15	88	82	109	117	145	127	83	1	14.79
MALDEN,	521	232	289	-	32	109	22	9	5	5	17	10	9	44	34	34	42	74	73	33	1	14.08
Marblehead,	140	66	74	-	1	15	1	2	5	2	5	2	1	5	6	6	14	28	19	28	1	18.47
MARLBOROUGH,	195	98	97	-	9	36	10	4	2	2	10	2	4	13	15	17	16	26	21	17	-	14.33
MEDFORD,	227	99	128	-	19	40	4	4	5	-	4	3	5	11	9	16	33	31	37	25	-	10.83
MELROSE,	175	87	87	1	13	20	5	1	1	3	2	1	4	15	22	9	19	26	33	14	-	12.87
Methuen,	128	49	79	-	19	15	5	2	1	1	4	1	-	9	8	10	13	29	23	7	-	14.88
Middleborough,	113	50	62	1	-	12	1	4	-	-	2	2	3	5	6	5	8	20	26	19	-	16.14
Milford,	177	101	76	-	5	25	3	5	3	4	4	4	6	16	19	13	16	25	22	12	-	13.48
Milton,	105	44	60	1	10	11	3	1	-	-	-	2	1	8	6	7	12	10	28	16	-	14.56
Natick,	130	72	58	-	7	10	-	3	-	1	7	2	1	11	9	8	14	24	28	12	-	13.14
NEW BEDFORD,	1,590	824	766	-	100	442	100	67	68	39	93	29	47	107	94	77	100	132	118	77	-	23.66
NEWBURYPORT,	262	119	143	-	11	31	9	4	3	-	2	4	8	22	20	11	38	33	47	30	-	18.09
NEWTON,	443	229	214	-	26	69	11	3	5	4	8	8	6	29	20	29	53	56	81	61	-	11.72
NORTH ADAMS,	381	201	180	-	35	68	21	9	12	11	9	10	16	41	25	26	34	39	36	23	1	13.67
NORTHAMPTON,¶	280	143	137	-	12	50	3	3	1	1	9	4	5	14	16	25	33	44	44	28	-	10.96

* Non-residents, 890 included. † State Farm, 69 not included. ‡ Soldiers' Home, 83 included.
§ Insane Asylum, 127 not included. ‖ 342 from one to five years; 101 from ten to twenty years. ¶ Insane Asylum, 62 probably included.

TABLE II. — *Concluded.*

	Total Deaths.	Males.	Females.	Sex Unknown.	Still-births.	Deaths under 1.	1-2.	2-3.	3-4.	4-5.	5-10.	10-15.	15-20.	20-30.	30-40.	40-50.	50-60.	60-70.	70-80.	Over 80.	Age Unknown.	Rate per 1,000.
North Attleborough, . .	101	40	61	-	9	17	9	4	2	1	-	3	3	7	5	5	8	13	14	10	-	13.19
Northbridge, ...	132	64	68	-	10	41	5	1	2	1	6	3	4	11	14	8	9	12	9	6	-	16.32
Norwood, ...	78	42	36	-	14	17	4	-	2	-	-	-	3	5	4	12	7	9	8	7	-	12.95
Orange, ...	60	29	31	-	4	9	2	1	-	-	2	1	1	1	4	6	8	9	10	11	-	10.68
Palmer, ...	141	73	68	-	5	39	10	7	7	3	5	2	1	7	8	6	12	11	14	9	-	16.85
Peabody, ...	208	103	105	-	5	31	17	5	1	-	2	2	9	10	21	18	23	21	33	14	1	17.08
PITTSFIELD, ...	359	179	180	-	22	56	15	8	4	1	4	6	15	30	33	34	38	50	37	27	1	15.89
Plymouth, ...	175	102	73	-	10	33	6	1	5	1	4	3	1	5	16	11	13	30	25	21	-	16.31
QUINCY, ...	352	180	172	-	25	70	18	7	4	3	11	7	7	27	16	39	34	34	41	34	-	13.52
Reading, ...	73	26	47	-	2	8	2	-	1	1	2	1	1	4	7	5	10	9	14	13	-	14.26
Revere, ...	141	72	69	-	12	28	4	4	5	1	5	1	2	7	11	15	15	15	17	11	-	11.08
Rockland, ...	74	36	38	-	2	4	2	1	-	1	-	-	1	8	7	8	6	9	16	11	-	13.89
SALEM, ...	739	386	353	-	36	159	33	18	12	8	18	17	14	44	50	51	65	93	82	73	2	20.04
Saugus, ...	93	45	48	-	6	19	2	1	-	-	1	1	4	2	8	5	10	15	16	9	-	17.11
SOMERVILLE, ...	955	501	454	-	58	170	33	19	14	10	22	11	19	68	76	64	77	149	148	75	-	14.02
Southbridge, ...	184	101	83	-	17	44	8	2	2	-	7	5	4	13	10	13	12	16	21	14	13	16.33
Spencer, ...	120	71	49	-	6	16	3	4	2	3	3	3	3	4	14	9	12	15	17	12	-	15.72
SPRINGFIELD, . . .	1,100	551	549	-	53	191	68	29	15	6	35	18	23	74	93	97	115	121	120	92	3	15.85
Stoneham, ...	115	61	54	-	7	9	2	4	-	-	1	3	2	7	7	8	18	14	21	19	-	18.56
Stoughton, ...	85	44	41	-	2	14	1	-	-	-	-	3	3	8	5	3	7	12	12	17	-	15.83
TAUNTON,*	645	350	295	-	34	114	26	19	4	4	14	8	11	41	44	55	76	82	91	55	1	15.92
Wakefield, ...	121	51	70	-	8	26	3	-	2	-	2	2	2	7	9	13	14	17	12	12	-	12.25
WALTHAM, ...	342	172	170	-	23	45	8	8	3	8	11	6	11	27	26	32	40	41	50	26	-	13.57
Ware, ...	111	64	47	-	10	29	8	1	2	1	6	1	1	8	9	11	7	10	10	7	-	12.86
Watertown, ...	142	72	70	-	15	26	3	1	-	1	-	1	5	15	15	15	16	11	19	14	-	12.82

Webster,	164	101	63	-	12	48	14	-	5	2	3	1	4	9	12	9	12	17	21	7	-	17.43
Wellesley,	37	19	18	-	4	5	2	1	-	-	-	-	-	2	-	5	4	7	3	8	-	6.63
Westborough,†	161	85	76	-	2	9	2	1	1	1	4	2	2	4	16	23	21	18	31	26	-	14.37
Westfield,	234	120	114	-	7	65	9	2	3	2	6	2	3	11	6	18	23	35	25	24	-	17.44
West Springfield,	136	77	59	-	7	22	6	10	4	2	10	1	5	8	9	5	9	9	19	17	-	17.68
Weymouth,	201	106	95	-	8	24	5	2	2	2	4	-	2	8	16	14	30	31	40	21	-	17.72
Whitman,	73	31	42	-	3	7		-	1	-	1	-	2	8	7	4	10	13	13	6	-	11.41
Williamstown,	57	23	34	-	6	8		1	1	1	-	2	-	6	3	2	4	6	9	13	-	11.20
Winchendon,	91	44	47	-	9	18		2	3	-	2	2	-	7	4	5	4	14	13	12	-	17.15
Winchester,	79	34	45	-	10	11	3	1	-	1	1	-	2	5	4	10	14	5	8	14	-	9.99
Winthrop,	71	44	27	-	3	8		-	-	-	-	1	1	9	3	7	7	12	13	4	3	9.89
WOBURN,	232	113	119	-	9	40	9	11	3	1	4	3	3	19	23	19	27	26	21	23	-	16.22
WORCESTER,‡	2,069	1,090	978	1	135	431	100	36	13	10	39	33	42	165	214	176	228	265	195	121	1	14.59
Totals,	41,210	21,026	20,176	8	2,765	8,803	1,685	827	557	359	1,077	559	829	3,094	3,537	3,398	4,077	4,784	4,374	2,763	44	16.14

* Insane Asylum, 109 probably included. † Insane Asylum, 82 included. ‡ Insane Asylum, 143 not included.

TABLE III.

Deaths from Specified Causes in Cities and Towns having more than 5,000 Inhabitants in Each.

	Consumption.	Smallpox.	Measles.	Scarlet Fever.	Diphtheria and Croup.	Whooping-cough.	Typhoid Fever.	Cerebro-spinal Meningitis.	Erysipelas.	Puerperal Fever.	Influenza.	Malarial Fever.	Cholera Infantum.	Dysentery.	Diarrhoea and Cholera Morbus.	Pneumonia.	Bronchitis.	Diseases of the Heart.	Diseases of the Brain and Spinal Cord.	Diseases of the Kidneys.	Cancer.	Suicide.	Accident.	Unknown or Ill-defined Causes.	All Other Causes.
Amesbury,	12	-	-	3	-	-	3	7	-	2	1	-	1	8	2	12	2	22	21	18	11	-	2	-	25
Amherst,	5	-	1	-	-	2	1	2	-	-	1	-	1	-	-	10	2	10	6	6	1	1	1	-	30
Andover,	12	-	-	-	1	-	1	-	-	-	-	-	-	2	-	3	8	14	9	3	5	-	7	-	28
Arlington,	10	-	-	2	2	-	-	5	-	-	-	-	-	-	-	15	-	9	-	-	6	-	4	-	72
Athol,	3	-	-	-	2	-	-	5	1	-	-	-	1	-	-	16	-	16	3	-	-	1	4	2	65
Attleborough,	28	-	-	1	-	2	4	8	-	1	1	-	7	-	-	20	4	21	11	10	14	-	9	-	33
BEVERLY,	26	-	3	-	5	3	3	-	-	-	-	-	7	1	2	22	8	38	17	22	9	2	11	-	52
Blackstone,	8	-	-	-	3	2	1	7	-	3	-	-	6	2	2	9	4	19	6	13	2	-	10	-	15
BOSTON,	1,227	13	50	65	214	108	119	47	34	23	83	-	180	22	463	1,265	288	992	593	563	511	81	477	126	3,070
Braintree,	9	-	-	1	2	-	2	4	-	-	3	-	1	1	1	10	-	17		-	11	-	8	-	41
Bridgewater,	6	-	-	-	-	-	2	1	-	-	-	-	1	-	2	8	3	14	8	[illegible]	2	-	2	6	11
BROCKTON,	64	-	-	4	4	8	5	19	-	-	7	-	9	1	-	19	2	48	33	14	19	7	15	-	216
Brookline,	29	-	1	6	4	3	2	1		-		2	4	-	-	82	9	46	21	17	16	3	7	1	88
CAMBRIDGE,	166	1	4	10	28	16	14	6		1	10		39	2	56	183	41	151	171	74	71	11	46	126	268
CHELSEA,	53	-	-	1	2	7	5	1		-			14	4	2	36	8	73	38	34	26	4	14	-	286
CHICOPEE,	27	-	3	42	9	4	4	-		-	1		25	-	7	36	9	22	49	20	4	-	18	-	127
Clinton,	16	-	1	-	4	-	3		2	-			11	8	5	20	2	21	2	6	4	2	12	2	89
Concord,	8	-	-	-	1	1	1	1		-	9		1	-	2	4	1	10	5	4	4	1	4	-	23
Danvers,	12	-	-	-	-	-	1	2		-		2	-	-	3	14	2	14	17	11	7	1	1	-	22
Dedham,	6	1	-	1	2	1	-	-	-	-			-	-	-	18	5	12	15	6	5	-	1	-	38
Easthampton,	5	-	2	-	-	-	1	2		-		2	2	-	1	7	4	4	1	-	2	1	2	-	25
EVERETT,*	40	-	-	2	7	6	2	1	1	-	2		14	-	2	23	9	43	2	11	17	2	7	1	148

FALL RIVER, . .	265	1	7	17	34	10	27	6	6	-	11	1	287	7	19	184	87	112	290	88	81	2	62	14	672
FITCHBURG, . .	38	-	4	-	7	22	2	1	-	-	2	-	9	-	-	40	26	47	6	9	22	4	16	2	202
Framingham, . .	14	-	-	-	3	5	2	-	-	-	-	5	3	-	1	26	4	23	19	6	13	-	8	1	36
Franklin, . . .	6	-	-	1	-	-	2	1	-	-	4	1	-	1	1	10	2	9	8	3	5	-	2	-	21
Gardner, . . .	21	-	-	-	4	6	1	15	1	-	10	-	11	-	-	26	6	15	8	10	11	2	18	-	36
GLOUCESTER, . .	27	-	-	1	38	3	6	2	-	-	2	-	5	-	4	16	7	26	10	1	24	3	7	-	243
Great Barrington, .	6	-	-	-	1	-	-	1	-	1	-	-	4	1	-	12	3	12	12	6	7	1	3	-	38
Greenfield, . .	8	-	-	-	-	-	1	6	1	-	1	1	1	1	1	17	1	12	9	11	8	2	8	5	36
HAVERHILL, . .	63	1	-	-	6	9	4	-	-	7	5	1	32	-	4	74	20	47	57	35	27	10	23	3	142
Hingham, . . .	6	-	-	-	-	-	-	-	-	-	3	-	-	3	-	8	-	8	8	1	1	1	5	4	22
HOLYOKE, . . .	77	-	15	6	11	7	5	1	2	5	11	-	69	3	45	97	29	40	21	55	24	8	27	-	288
Hudson, . . .	10	-	2	3	-	-	-	1	-	-	-	-	2	-	-	7	-	11	-	3	4	-	3	-	32
Hyde Park, . .	21	-	-	5	-	3	2	1	-	-	-	1	3	1	-	27	2	10	8	8	10	1	6	-	92
LAWRENCE, . .	127	1	10	10	32	12	23	4	1	3	2	3	107	4	8	108	37	82	92	78	39	4	33	52	330
Leominster, . .	18	-	-	1	2	1	1	-	-	2	-	-	6	2	1	19	1	24	7	11	12	1	11	-	58
LOWELL, . . .	132	-	-	8	34	15	26	2	2	1	10	1	157	10	9	190	73	153	92	104	75	18	60	-	730
LYNN, . . .	49	2	-	1	27	17	14	5	2	2	1	3	24	5	6	82	23	109	85	72	57	2	36	13	484
MALDEN, . . .	47	-	1	8	7	4	7	-	-	-	-	-	8	1	4	40	14	59	73	81	29	2	2	-	184
Marblehead, . .	8	-	-	-	5	-	-	1	1	-	-	-	1	-	1	18	5	20	15	5	7	1	2	-	55
MARLBOROUGH,	16	-	2	3	3	2	1	17	-	-	-	-	10	2	-	20	2	21	1	8	7	-	3	2	75
MEDFORD, . .	7	-	-	1	5	1	3	-	-	-	-	-	1	-	-	29	8	25	-	5	15	2	4	-	120
MELROSE, . . .	22	-	-	-	1	6	1	-	-	1	3	-	-	-	-	15	2	20	22	16	15	-	12	20	19
Methuen, . . .	20	1	-	-	5	1	3	6	-	-	3	-	6	1	3	9	4	14	4	2	8	3	5	-	80
Middleborough, .	12	-	-	2	-	-	2	6	-	-	1	-	-	1	-	9	1	22	9	6	4	-	1	-	37
Milford, . . .	13	-	-	-	7	-	1	10	-	-	2	-	3	-	7	13	5	28	2	12	7	1	7	-	59
Milton, . . .	7	-	-	1	-	-	1	-	-	-	1	-	1	1	-	6	3	6	-	-	5	-	2	-	71
Natick, . . .	11	-	-	-	5	-	1	3	-	-	1	-	1	-	1	14	-	20	-	6	8	-	4	-	55
NEW BEDFORD, .	116	-	1	148	32	7	28	2	-	1	2	-	104	2	9	169	66	124	77	78	46	4	-	-	574
NEWBURYPORT, .	18	-	-	-	8	1	2	2	1	2	-	-	3	-	-	19	7	19	3	18	15	2	8	2	132
NEWTON, . . .	23	-	-	-	6	2	3	4	2	-	6	-	1	5	7	36	15	45	18	36	20	2	7	-	205
NORTH ADAMS, .	21	-	1	18	16	2	11	-	-	2	1	-	10	-	4	31	5	17	17	18	12	2	19	1	178

TABLE III. — *Concluded.*

	Consumption.	Smallpox.	Measles.	Scarlet Fever.	Diphtheria and Croup.	Whooping-cough.	Typhoid Fever.	Cerebro-spinal Meningitis.	Erysipelas.	Puerperal Fever.	Influenza.	Malarial Fever.	Cholera Infantum.	Dysentery.	Diarrhœa and Cholera Morbus.	Pneumonia.	Bronchitis.	Diseases of the Heart.	Diseases of the Brain and Spinal Cord	Diseases of the Kidneys.	Cancer.	Suicide.	Accident.	Unknown or Ill-defined Causes.	All Other Causes.
NORTHAMPTON, .	25	-	-	2	6	3	1	-	2	-	2	-	6	3	1	13	12	31	41	10	5	4	15	5	93
North Attleborough,	14	-	-	-	1	-	1	-	-	1	3	2	-	7	-	12	3	8	5	7	4	4	-	-	29
Northbridge, . .	12	-	-	-	5	-	1	7	1	1	-	2	12	-	2	16	2	14	9	12	4	2	4	-	25
Norwood, . . .	14	-	-	-	2	2	-	3	-	-	-	-	4	-	1	4	2	12	7	6	1	2	3	-	15
Orange, . . .	3	-	-	-	-	1	1	3	1	-	-	-	-	-	-	6	-	7	5	7	4	1	2	-	19
Palmer, . . .	16	-	-	8	5	3	-	1	-	-	1	-	5	3	2	12	2	18	13	5	6	-	4	7	30
Peabody, . . .	22	-	-	1	3	5	1	7	-	1	-	-	6	3	-	7	7	34	21	17	6	-	3	-	64
PITTSFIELD, . .	30	-	3	-	3	1	6	10	2	1	-	-	7	6	4	37	13	33	45	22	11	3	22	9	86
Plymouth, . .	14	-	2	4	5	5	1	1	-	-	-	-	4	-	4	1	3	25	11	6	10	4	1	3	71
QUINCY, . . .	28	-	1	-	11	9	2	-	-	-	8	-	5	2	18	27	8	49	46	25	23	4	14	-	70
Reading, . . .	11	-	-	-	-	-	1	2	1	-	1	-	-	-	1	6	4	8	10	4	4	-	2	2	16
Revere, . . .	14	-	-	-	3	1	2	2	-	-	-	-	5	1	2	19	4	14	-	11	2	3	6	-	51
Rockland, . . .	12	-	-	-	1	-	1	4	-	-	-	-	1	-	3	6	2	13	5	5	1	1	4	2	13
SALEM, . . .	82	-	-	-	24	13	16	-	2	-	3	-	42	3	6	59	29	76	52	39	36	2	15	-	240
Saugus, . . .	6	-	-	-	-	2	1	1	-	1	-	-	1	1	3	9	7	12	4	3	6	1	-	-	35
SOMERVILLE, . .	82	-	-	10	19	12	10	32	1	-	11	-	10	5	4	122	39	92	13	30	44	5	27	-	387
Southbridge, . .	8	-	-	-	-	-	1	2	-	6	-	-	5	6	7	25	2	8	14	11	9	-	2	10	68
Spencer, . . .	16	-	2	2	4	-	-	2	-	-	1	-	2	-	-	16	3	17	10	7	3	1	2	-	32
SPRINGFIELD, . .	97	-	17	16	21	27	17	2	2	8	17	2	15	3	36	113	22	101	22	92	60	8	56	13	333
Stoneham, . . .	8	-	1	-	-	-	1	5	-	-	1	-	-	1	1	8	1	9	23	8	12	-	5	23	8
Stoughton, . .	15	-	1	-	1	-	-	-	-	-	2	-	1	1	-	5	1	13	12	6	1	1	3	-	22
TAUNTON, . . .	58	-	-	5	9	4	5	4	4	2	9	5	23	4	23	73	18	40	3	37	19	4	1	1	294
Wakefield, . .	20	-	-	-	-	2	2	5	1	-	-	-	-	-	-	10	1	14	8	2	6	3	3	-	44
WALTHAM, . .	34	-	-	1	5	3	8	2	-	-	3	-	3	-	3	33	11	44	29	12	13	-	9	-	129
Ware, . . .	9	-	2	3	1	-	-	-	-	-	-	-	4	-	1	8	1	5	7	9	1	2	2	-	56

Watertown,	11	-	-	-	-	1	1	-	-	-	3	-	1	1	-	11	2	16	23	6	4	2	6	19	35
Webster,	9	-	-	-	5	2	-	3	-	-	-	-	8	8	3	17	7	20	-	-	6	2	3	-	71
Wellesley,	2	-	-	1	-	-	-	2	-	-	-	-	-	-	3	5	3	5	5	-	4	-	1	-	6
Westborough,	9	-	2	5	-	1	-	4	-	-	-	-	-	1	-	5	2	13	80*	5	6	4	3	-	21
Westfield,	16	-	2	2	8	2	4	-	-	-	2	1	5	2	-	16	8	23	1	13	14	-	9	-	106
West Springfield,	10	-	3	5	4	5	3	3	2	-	1	-	2	-	-	13	4	8	-	9	2	-	6	-	56
Weymouth,	19	-	-	-	2	2	2	3	1	-	-	-	4	-	1	29	4	30	23	19	10	-	9	10	33
Whitman,	12	-	-	1	-	-	1	1	-	-	-	-	-	-	-	4	3	17	6	5	5	-	2	-	16
Williamstown,	4	-	-	-	-	-	-	-	-	-	1	-	-	-	1	7	3	8	7	5	2	-	2	1	16
Winchendon,	9	-	-	-	-	-	-	2	-	-	-	-	1	1	-	10	-	11	14	2	2	1	-	-	38
Winchester,	5	-	-	-	1	-	-	-	-	-	1	-	3	1	1	5	6	12	5	4	7	-	-	-	28
Winthrop,	7	-	-	-	-	-	2	-	-	-	-	-	2	-	-	4	-	5	5	5	4	-	1	-	36
Woburn,	23	-	-	2	1	1	-	2	2	-	1	1	11	2	1	22	4	13	2	19	6	1	7	-	111
WORCESTER,	213	-	32	7	11	14	17	-	4	6	-	4	113	3	22	260	54	222	304	100	73	13	72	-	522
Totals,	4,000	21	176	447	750	420	463	339	89	84	272	42	1,504	160	839	4,208	1,161	3,896	2,848	2,158	1,801	268	1,387	488	13,348

* These were mostly deaths in the insane hospital.

	Homicide.
BEVERLY,	1
BOSTON,	17
BROCKTON,	1
CAMBRIDGE,	1
Franklin,	1
HOLYOKE,	2
LAWRENCE,	2
LOWELL,	1
LYNN,	1
MEDFORD,	1

	Homicide.
Northbridge,	1
QUINCY,	2
Revere,	1
WORCESTER,	3

	Actinomycosis.
BOSTON,	1

	Tetanus.
PITTSFIELD,	5

TABLE IV.

uths from Specified Causes, 1903, in Cities and Towns required to report to the State Board of Health, Death-rates per 10,000 (1899–1903), Deaths per 1,000 from All Causes, 1899–1903.

Causes of Death.	Deaths. 1903.	Mortality per 10,000 of the Population.					Deaths per 1,000 from All Causes.				
		1903.	1902.	1901.	1900.	1899.	1903.	1902.	1901.	1900.	1899.
Consumption,	4,000	15.66	16.38	17.63	18.56	17.91	97.06	101.06	104.58	101.60	103.70
Smallpox,	21	0.08	1.12	0.39	0.008	0.06	0.51	6.89	2.30	0.046	0.33
Measles,	176	0.69	0.92	0.73	0.99	0.66	4.27	5.66	4.35	5.44	3.80
Scarlet fever,	447	1.75	1.13	1.46	1.51	0.84	10.85	6.99	8.64	8.29	4.85
Diphtheria and croup,	750	2.94	3.22	4.40	5.87	3.99	18.20	19.84	26.13	32.12	23.08
Whooping-cough,	420	1.64	0.96	0.84	1.27	1.11	10.19	5.96	4.99	6.85	6.41
Typhoid fever,	463	1.81	1.88	1.96	2.25	2.31	11.24	11.59	11.61	12.34	13.40
Cerebro-spinal meningitis,	339	1.33	1.39	1.46	1.63	1.73	8.23	8.60	8.69	8.91	10.03
Erysipelas,	89	0.35	0.44	0.47	0.66	0.50	2.16	2.74	2.79	3.66	2.88
Puerperal fever,	84	0.33	0.32	0.34	0.37	0.20	2.04	1.98	2.00	2.01	1.17
Influenza,	272	1.06	0.43	1.90	2.28	1.57	6.60	2.64	11.29	12.44	9.09
Malarial fever,	42	0.16	0.15	0.19	0.22	0.21	1.02	0.94	1.14	1.23	1.20
Cholera infantum,	1,504	5.89	6.05	6.11	9.87	8.20	36.50	37.36	36.28	54.10	47.45
Dysentery,	160	0.62	0.70	0.72	0.75	1.00	3.88	4.35	4.25	4.12	5.79
Diarrhœa and cholera morbus.	839	3.29	3.71	3.54	3.84	1.84	20.36	22.88	20.99	21.00	10.67
Pneumonia,	4,208	16.48	16.07	16.66	18.40	17.89	102.11	99.21	98.83	100.70	103.60
Bronchitis,	1,161	4.55	4.69	4.47	5.09	5.18	28.17	28.96	26.50	27.88	30.00
Diseases of the heart,	3,896	15.25	15.66	15.70	16.16	14.85	94.52	96.40	93.12	88.45	86.00
Diseases of the brain and spinal cord.	2,848	11.15	12.17	10.41	10.81	11.99	69.10	75.12	61.76	59.00	69.42
Diseases of the kidneys,	2,158	8.45	7.38	7.75	7.32	7.13	52.36	45.57	46.01	40.05	41.30
Cancer,	1,801	7.05	6.91	6.19	6.53	6.06	43.70	42.66	36.75	35.75	35.07
Suicide,	268	1.05	1.02	[illegible].05	0.99	1.07	6.50	6.30	6.22	5.39	6.18
Accident,	1,387	5.43	5.40	5.39	5.20	5.20	33.66	33.31	31.95	28.50	30.12
Unknown or ill-defined causes.	488	1.91	1.64	1.77	2.63	2.56	11.84	10.11	10.52	14.38	14.80
All causes,	41,210	161.32	162.07	168.58	182.60	172.70	-	-	-	-	-

HEALTH OF TOWNS.

[591]

HEALTH OF TOWNS.

The following digest consists chiefly of extracts from such annual reports of local boards of health for the year 1903 as have been received at the office of the State Board of Health.

Prominent among the topics considered in these reports are the gradual decline in the death-rate from infectious diseases and the rapid decrease in the epidemic of smallpox, which began in the spring and summer of 1901, reached its height in the following winter and spring and prevailed with somewhat lessened severity throughout 1902 and 1903, the total reported cases in 1901 being 778; in 1902, 2,305, and in 1903, 417.

The establishment of laboratories in the larger cities and towns has given efficient aid in the management and prevention of the spread of infectious diseases, while the erection of isolation hospitals is proving useful in the same direction.

Scarlet fever prevailed throughout the year with somewhat increased severity. The fatality of the disease, however, varied very much in different cities and towns, as reported in the annual reports of the local boards. That of New Bedford, for example, having been 25.8 per hundred reported cases, or 148 deaths in 574 cases, and that of Chicopee being 26 per cent., or 42 deaths in 161 cases, while the fatality from this cause in Boston was only 4.4 per cent., in Cambridge 5.3 per cent., in Lowell 5.5 per cent., and in Woburn less than 1 per cent. (2 deaths in 231 cases).

This portion of the report also contains certain reports of Medical Inspector F. L. Morse relative to outbreaks of typhoid fever which occurred in the summer and fall of 1903, together with a summary of visits and inspections made by him for the purpose of aiding local authorities in controlling the spread of smallpox.

The following summary presents in tabular form the routine bacteriological work of the principal cities.

Bacteriological Work performed by Local Boards of Health, 1903.

	Diphtheria Cultures.	Tuberculosis.	Typhoid Fever.	Malaria.	Packages of Antitoxin Distributed.
Boston,*	8,780	2,914	1,088	98	-
Brockton, ...	267	169	65	40	-
Brookline, ...	777	116	58	18	-
Cambridge, ...	1,294	193	194	-	-
Fitchburg, ...	52	125	55	-	-
Greenfield, ...	27	-	-	-	-
Holyoke, ...	268	-	-	-	-
Lowell, ...	1,043	-	242	3	-
Lynn, ...	1,011	-	-	-	-
New Bedford, ...	401	47	2	-	-
Newton, ...	288	-	-	-	-
Palmer, ...	74	-	-	-	-
Somerville, ...	817	137	72	8	-
Springfield, ...	787	-	-	-	-
Waltham, ...	691	45	-	-	-
Worcester, ...	1,274	403	-	-	-
State Board of Health, ...	3,632	1,006	226	32	41,133

* Glanders, 175; other diseases, 46.

AMESBURY.

We have had but few complaints, and owing to the cool summer much less trouble has arisen than in former years.

The school-houses have been kept in a much better condition than in former years through the prompt action of the superintendent of schools in reporting all cases which needed attention as soon as possible after he had been informed of trouble.

ARLINGTON.

During the year of 1903 diphtheria and scarlet fever have been epidemic in certain sections of the town. A large number of these cases were in families in which the mother, or another untrained attendant, cared for the patients, and where the quarantine could not be so thoroughly carried out as desired by the attending physician. In many cases contagion was unnecessarily spread to the other children of the family, or to the children of other families, because the attendant failed to carry out the strict quarantine rules.

Too often in diphtheria the attendant in the quarantine relaxes her vigilance as soon as the child's throat is free from membrane, feeling that the

anger has passed. That child is a menace to every one, especially chilren, until cultures from the throat are negative, and the sooner people əalize this the sooner will the spread of diphtheria diminish.

Medical Inspection of Schools.

The total number of children examined during the year 1903 was 899, f which number 93 were sent home for the following reasons: —

Pediculi,	36	Whooping-cough,	3
Sore throat,	11	Mumps,	1
Vaccination,	6	Chicken-pox,	1
Revaccination,	10	Erythema,	1
Pink eye,	8	Itch,	1
Ringworm,	4	Scarlet fever,	1
Stye,	10		

BEVERLY.

A careful inspection of the bakeries in our city has been made and copies f the Revised Laws relating to them posted therein. They were found to e, with one exception, in good condition.

The city dumping places are now very generally used by the people of ıe city for the disposal of all kinds of rubbish and waste matter. These umps are well taken care of and kept as clean as possible.

BOSTON.

The total number of deaths for the year was 10,632, a decrease from the revious year of 351 deaths. The death-rate for the year, as calculated, 'as 17.69 per 1,000 inhabitants. This rate is less by 1.04 than that of ıe previous year, and the lowest on the city's record. There were 2,797 eaths from infectious diseases, including consumption, a decrease of 301 eaths. There were 111 less deaths from diphtheria and croup than in 902, with a proportionate decrease in the number of cases. The percentage f deaths to the number of cases of diphtheria reported was 10.32, as against 1.33 per cent. the preceding year. There were 65 deaths from scarlatina, 2 less deaths than in the preceding year, and 52 deaths less than the averge of the five previous years. Typhoid fever has caused 119 deaths durıg the year, 20 less deaths than the preceding year.

Disinfection, 1903, — Materials Used.

Formaldehyde,	1,975 gallons.
Alcohol for heat,	850 gallons.
Chloride of lime,	53,000 pounds.
Bichloride of mercury,	925 pounds.
Chloride of sodium (in mixing),	1,100 pounds.

Medical Inspection of Schools.— Summary.

Specific infectious diseases,	577
Oral and respiratory diseases,	1,567
Diseases of the ear,	119
Diseases of the eye,	742
Diseases of the skin,	5,137
Miscellaneous diseases,	4,485
Found free from disease,*	9,417
Total,	22,044

Number of pupils examined in the schools,	22,044
Number recommended to be sent home,	3,721
Number of consultations with teachers (about pupils returning to school, etc.),	2,649

Hospital for Consumption. — The pressing need of greater hospital accommodations for consumptive patients is brought to our attention with constantly increasing force. The moderate provision which has been made at Long Island is good, as far as it goes, but is altogether inadequate to meet the demand for the care of even the worst cases.

Milk. — The inspection of milk and other dairy products, as authorized by chapter 206, Laws of 1859, and now under chapter 56, Revised Laws, pertaining to their chemical composition, has been vigorously and justly carried on by the inspector, Dr. Harrington, from year to year, with increasing success and great advantage to the consumers. This law was reinforced in 1898 by regulations made and adopted by the board of health, which impose greater care on the part of the producer, the contractor and the retailer in securing the delivery of cleaner and uninfected milk. These regulations have been advertised in the city and sent to thousands beyond the city limits who produce milk for consumption in Boston. Their enforcement has lessened the chances of infection at the sources of supply, diminished the most faulty handling of milk, and cut off many retail licensees and producers in the city whose personal habits and environment were too unclean for the business.

The next step in the interest of cleaner milk is about to be taken by the board of health, by which the temperature of the milk at the time it reaches the city, and until its delivery to the consumer, must not be at or above 50° Fahrenheit, and the number of bacteria found in the milk must not exceed five hundred thousand to each cubic centimeter of the milk. This bacterial limit, though large, calls for an improvement on the ordinary condition of the milk, and will undoubtedly be cut down from time to time, after the work has been begun.

* Includes about 3,000 found free from pediculi.

3. Search for the Shiga bacillus in summer diarrhœas and tests of the serum proposed for the treatment of these diseases.

4. An epidemic at the Boston Insane Hospital.

5. A new and simple method of growing anaerobes.

6. An electrolytic process for disinfection of clothing in laundries.

7. Miscellaneous tests. An appendix giving the results of the regular routine work follows, containing a summary of six years work ending Jan. 31, 1904.

Inspection of Animals. — The inspector of animals reports 68,343 animals slaughtered at the abattoir. Animals weighing 63,309 pounds were condemned.

Tuberculosis was found in 97 cattle and 4 swine. There were 25 cases of actinomycosis.

Inspection of cattle kept in the city for milk production was continued during the year. Nine were found to be tuberculous and were quarantined; 253 cases were suspected of being infected with glanders, of which 188 were found infected.

One case of rabies was reported, a dog belonging to a traveling theatrical company.

Brockton.

Better accommodations for the care of contagious diseases should be provided at once. The need of a hospital was never more apparent than at the present time. With the extreme cold weather of the winter, it has been simply impossible to furnish proper care and comfort at the old farm house that is now used for the hospital.

Brookline.

In 1903 long-continued rains, followed by spells of warm weather, made conditions which were very favorable for mosquitoes, and a great increase in their numbers was noticed not only in Brookline but everywhere else. The work during 1903 was systematized and made more effective, and more effort was made to induce land owners to remove conditions on their premises favorable to mosquitoes. The petrolizing of the street catch-basins, which were found to be full of mosquitoes, was efficiently carried out by the street department.

A circular letter was sent to 32 property owners to induce them to do away with the unnecessary standing water, affording breeding places for mosquitoes on their premises. Of this number, 6 had filling done and thus permanently removed the mosquito-breeding places on their lands; permanent work was started although not fully completed on the property of 3 more; and the water areas on 10 other premises were petrolized periodically through the season.

The crying need of more adequate hospital accommodations for poor

atients in the advanced and most infectious stages of consumption has een felt a number of times in Brookline the past year. It is practically npossible for such a consumptive, if living in a tenement, not to be a erious menace to the health of the members of his own family, and to ome extent to that of other families. It is earnestly hoped that the Com- ionwealth may some time recognize this great need and provide more enerously for the isolation and better care of this large and neglected lass of patients, especially in this vicinity.

The systematic medical inspection, under the supervision of the agent f the board, of the pupils of the public schools and of the parochial school ras continued throughout the year, but the prevalence of communicable isease was not so great as to require daily inspections.

It is believed that the freedom of the town from serious epidemics is argely a result of the school inspection.

It is hoped by the writer that in the near future the medical inspection of chool pupils may be extended to include an annual examination of the yes, ears and teeth of all pupils, excepting, perhaps, those of the high chool. Of the advantages of the proposed inspection by specialists there an be no doubt.

The general health of the town the past year, as shown not only by the ower mortality but also by the testimony of many physicians and others, as been somewhat better than usual. This improvement may be attributed n part to more favorable weather conditions, and in part to factors more r less under human control.

Among the means of improving still further the general health and rell-being of the citizens, especially of the younger portion, the value of ystematic exercise, out of doors when possible, but in a well-ventilated ymnasium at other times, certainly deserves consideration.

The proposed municipal gymnasium, recently indorsed by the citizens in own meeting, will, in the writer's opinion, be a means of furnishing not nly the school pupils but hundreds of other young people, both men and romen, just the kind of exercise and recreation needed to offset the in- urious effects of the sedentary occupations that many are obliged to ollow.

Research Work. — Experiments to determine the importance of footwear a the transmission of contagious disease have been carried on during the ast year, and also experiments in disinfecting the clinical thermometer. t is hoped to publish the results of this work in the near future.

Board of Health Hospital. — Of the 65 patients admitted to the hospital uring the year 7 came as private room patients, of whom 5 were from Boston.

35 were cases of diphtheria.
25 were cases of scarlet fever.
5 were cases of measles.

After a year's experience with the new hospital, a complete set of rules and regulations for the government of the officers and employees of the hospital has been prepared, and, after careful revision by the board, has been adopted.

The nursing has been done by graduate nurses from the Boston City Hospital, assisted by experienced pupil nurses from the New England Baptist Hospital, and when necessary by other nurses. The matron and head nurses give a special or post-graduate course of instruction of from six to eight weeks to the junior nurses, and the arrangement works well.

It has been gratifying to note the more general use made of the hospital by the town the past year. Not only children from tenements, but both adults and children from the homes of a number of the well to do have been isolated and cared for in the hospital, some in the private rooms and some in the wards. The proportion of adults in the hospital has been much larger than ever the past year, and the proportionate number of all the infectious cases in the town taken care of in the hospital has been quite large.

Cambridge.

The board of health issued circulars and regulations during the year upon the following topics: —

Consumption	Infant feeding and care.
Sanitary condition of barber shops.	Ventilation.
Sanitary condition of street railway cars.	Transmission of disease by milk bottles.

Medical Inspection of Schools. — The diseases discovered in the schools and the number of cases were as follows: —

Chicken-pox,	14	Diseases of eye,	92
Measles,	1	Diseases of nervous system,	11
Mumps,	8	Diseases of respiratory system,	10
Scarlet fever,	1	Diseases of skin,	110
Whooping-cough,	42	All other diseases,	192
Pediculosis,	192		
Diseases of ear,	10	Total,	683

We recommend a new hospital for cases of diphtheria and scarlet fever, with a ward for the care of measles. We also recommend that a proper hospital be constructed for the care of smallpox cases. We recommend the construction of a hospital for cases of consumption. In fact, we believe that there should be proper buildings constructed for the reception of persons with the various infectious diseases. It would tend to promote the health of the community, would be appreciated by our citizens and would be in line with the steps taken by progressive municipalities.

CHELSEA.

During the year there have been but 2 cases of smallpox. These were taken to the smallpox hospital and cared for, with no fatal results. On February 21 the hospital was closed and was not used again throughout the year. October 12 the board of aldermen appropriated $600 for the purpose of constructing an ell to the hospital, and for making other necessary repairs. These repairs were suggested by the health officer, who reported a deplorable state of affairs existing there.

We have been fortunate in having had fewer contagious cases during 1903 than for several years past. The board feels that this is largely due to better sanitary conditions, owing to a more unanimous compliance with the law, especially throughout the tenement districts.

CHICOPEE.

Rules were adopted by the board in June relative to barber shops. The agent has inspected these shops from time to time and finds that considerable improvement has been made.

During the spring months scarlet fever was unusually prevalent, there being 161 cases reported to the board for the year. The type of the disease was very severe, there being 42 deaths. Much of the disease was undoubtedly spread by children having it in a mild form. The family employing no physician, the case would not be reported to the board, the child would be allowed to mingle with others while desquamating freely, thus unconsciously spreading the disease.

Fewer cases of diphtheria were reported than for years. This is due, in our opinion, to the more general use of antitoxin, which is furnished free by this department to the medical profession, from the supply given by the State Board of Health.

CONCORD.

Our death-rate this year, for some unexplainable cause, is the largest ever recorded, with one exception. The number of serious contagious diseases reported is, on the other hand, the smallest.

In all cases of death from tuberculosis the board has fumigated the premises, as it seems to be acknowledged that consumption is contagious to a more or less extent, and it is always best to act on the line of safety.

DANVERS.

During the past year the medical member of the board has visited various schools, when it seemed advisable, to examine scholars for signs of scarlet fever and other contagious diseases, in order that suspicious cases might be removed. In some cases rooms and books were cleansed and fumigated.

A teacher in the high school contracted a mild case of scarlet fever; the school was closed for a sufficient period for the safety of the scholars but no new cases developed.

Where it has been necessary to quarantine cases of contagious disease we have not been guided by any hard and fast rule but have used our best judgment in each case. If the wage earner has been prevented from work, which now very seldom happens, the board of health has taken care of the family.

Dedham.

The scarlet fever cases to a large degree were reported in February and March of the year 1903, and the board took immediate measures to determine, if possible, the means by which a spread of this disease was so rapid. It was found that a dairy in a neighboring town was the source of contagion. Inquiry was at once made in the town of Hyde Park, and it was found that a similar condition existed there. The boards of health of the towns of Hyde Park and Dedham at once took action in regard to the situation, and the place was visited, and all the cans, milk receptacles and premises thoroughly scalded and sterilized. Stringent rules were passed also in regard to the removal of any cans, bottles or other milk receptacles from any place where a contagious disease existed, and all milkmen were notified of these rules. This action produced an immediate effect on the number of cases reported, and the board believe that a number of these cases of scarlet fever were communicated by means of these receptacles being passed from one house to the other. This method of distributing milk, while extremely convenient and efficient, is in many cases unsanitary and open to grave suspicion. The board have, therefore, required that no such method of milk distribution shall be pursued in places where cases of contagious diseases exist.

Fall River.

The necessity for a properly equipped contagious disease hospital for the care of scarlet fever, diphtheria or measles was made more apparent during the past year, when the cottage on Highland Avenue was occupied by a scarlet fever case and diphtheria appeared at one of our public hospitals and had to be refused admission to the former for fear of exposing both patients, there being no facilities at the cottage for isolating one disease from the other.

Fitchburg.

Strict quarantine in all contagious diseases has been ordered by the board and well maintained. The public apparently appreciated the liberal action of the board of health in allowing the wage earners in families having a case of contagious disease to work, provided they have not come into intimate contact with the patient; but in all such cases the clothing was previously fumigated.

As we stated last year, quarantine regulations can be more satisfactorily enforced if this city had an isolation hospital for persons sick with diphtheria or scarlet fever. At a meeting of the board held March 3 it was voted to call the attention of the city government to the necessity of establishing an isolation hospital for the care and treatment of persons sick with contagious diseases. On February 2 the board adopted the following: —

The period of isolation in cases of scarlet-fever patients shall be not less than two weeks from the appearance of the eruption and the patient shall remain in quarantine until desquamation has entirely ceased.

The beginning of a typhoid fever epidemic appeared in September among 7 persons taking all or a part of their meals at a certain boarding house, but prompt action of the board averted further trouble and rigid and thorough inspection of the premises disclosed no local cause of the disease. It was probably imported from other towns by those who took some of their meals elsewhere and transmitted the disease to their fellow table boarders. The milk supply of this boarding house was carefully investigated. Twenty-four dairies were inspected that furnished the milk. At none of these farms was any evidence of typhoid fever found and the surroundings were in cleanly condition.

Haverhill.

There has been a decrease in all contagious diseases excepting smallpox and whooping-cough. There were 9 cases of smallpox, with 1 death. The origin of 3 of these cases we have not been able to discover; but presumably the source of infection was in the workroom, which has since been thoroughly disinfected.

In January an order was passed requiring the vaccination of all the inhabitants who had not been successfully vaccinated.

Four persons who had been indirectly exposed to smallpox, and who refused to be vaccinated, were summoned into court. When their cases were called it was shown that they had been vaccinated between the time of the summons and their appearance in court. Their cases were therefore dismissed without being tried.

Holyoke.

Such inspection of bakeries and their surroundings as is prescribed by law have been made. In a majority of cases these important places, where so much of our food product is manufactured, were found to be in a good general condition.

Twenty-four bakeries are at present in operation in the city. The board still endeavors to use its influence against cellar bakeries, and would advise legislation against the establishment of the same.

Thirty-four unsanitary basement and kitchen barber shops have been closed, and it is with pleasure that the board reports all barber shops at present complying strictly with the rules.

There are comparatively few vaults remaining in the city, and wherever sewer privileges have allowed, the use of the vault has been condemned.

The large amount of sewage discharged directly from the mills into the canals in its course through the city is objectionable from a sanitary point of view, and the public health demands that some other disposal of this sewage should be made.

With the exception of an epidemic of measles the city has been very free from disease of a contagious nature during the year. Smallpox again made its appearance, but was of a mild character and was readily controlled.

The board would once again call attention to the imperative need of a hospital for the care of diseases of a contagious nature, especially diphtheria and scarlet fever. With our large tenement districts it is evident that we should have such a building at our command in the city.

Hudson.

The board of health congratulates the citizens of our town on the public spirit shown in pushing the sewer question forward. A sewerage commission has been chosen, plans adopted and a pumping station is being built, — all important steps in the right direction to make our town and its homes cleaner by providing sewers to take the sewage and waste to the sewer beds on the outskirts of the town.

The board of health has fumigated all houses the past year where it was practical so to do, where contagious diseases have existed.

Lowell.

In October an examination was made of a large family living in a crowded tenement block in which several deaths from consumption were said to have occurred within a few years. The family was found to consist of 8 members, 4 males and 4 females, ranging in age from six to forty-two years. Three cases of pulmonary tuberculosis were found, a girl of ten years and two young men of seventeen and twenty years. The intention of the health department was to send those infected with the disease to a hospital for treatment and to remove the rest of the family temporarily to another tenement until the old one could be thoroughly disinfected, but the offer was declined by the family.

Observations upon the typhoid epidemic of August, 1903, are presented in this report, but are also elsewhere given in the report of Medical Inspector Morse.

In Lowell the average number of deaths during the decade 1890–99 was 1,929, and the death-rate 23.13 per thousand living. During the four years 1900–1903 the average annual number of deaths was 1,957, and the death-rate 19.83.

month still showed the presence of colon bacilli in the water. Of these cases, 10 proved fatal, and the ill effects of the introduction of the polluted river water for a few hours only was evident during the succeeding four months.

Lynn.

During the year 1903 there were admitted to the hospital 124 cases of diphtheria and 21 cases of scarlet fever. One case in addition to the above mentioned was successfully treated for a complication of diphtheria and scarlet fever.

One thousand seven bottles of antitoxin have been used in the treatment of diphtheria patients at the hospital, and 50 more for the immunizing of people in the families from which patients were removed to the hospital. In all, 136 persons were thus immunized.

A public vaccination was begun January 15 and continued until February 3. A corps of twenty-eight physicians was employed. The doctors vaccinated and inspected more than 30,000 people. The schools and principal factories were visited and as far as possible a house-to-house canvass made. A surprisingly large number of people were found who had never been vaccinated. The number who refused was small. The doctors did their work conscientiously and well. We have had no cases since the work was done. We are aware that the city is not perfectly protected from smallpox, but feel sure that it is much more so since this measure was adopted.

Malden.

The general health of the city for the year was very satisfactory, the death-rate being 14.36 per cent. per thousand on an estimated population of 36,276.

In October the board appointed two physicians as agents for the purpose of medical inspection of the schools. The wisdom of such a course was eminently justifiable from the fact that over 300 cases in three months were examined by said physicians and a large number of pupils were excluded from school, thus preventing possible contact with other pupils and further contagion.

New Bedford.

During the past year the collection of garbage has been done more satisfactorily than in any previous year. Not only has more territory been covered but modern collecting wagons have replaced the old ones, improving not only the appearance of the teams but adding greatly to their sanitary condition. The destruction of the garbage has not been as satisfactory. Our opinion is that the disagreeable odors complained of are present during certain conditions of the atmosphere, and while we do not consider them as unhealthy, some action must be taken to remedy them. We are also of the opinion that such odors are due to the present method employed in

destroying the garbage, and could be entirely obliterated by the addition of more modern machinery.

June 30 the city council designated the city property committee to act with our board on the question of the advisability of building an isolation hospital for the care of diphtheria and scarlet fever. Plans were drawn according to our suggestions and work is now progressing upon the buildings. The hospital will consist of two wards, one for diphtheria and one for scarlet fever, with an administration building between. There will be accommodations for about 50 patients, and the building is so arranged that more rooms can be economically furnished if necessity for the same occurs.

The number of medical school inspectors was increased from two to four at the beginning of the year, with the result that the schools have been thoroughly inspected and the number of visits to the same have been doubled. During the year 85,000 examinations were made, and 233 were recommended to be sent home.

Disinfection in cases of smallpox, scarlet fever and diphtheria is compulsory, and during the year 1,660 living rooms in various buildings of the city have been thoroughly disinfected with formaldehyde gas. In addition, all school-houses were disinfected during the past summer, a measure which we consider as conducive of adding to their safety for the ensuing school year.

Newton.

The total number of deaths from all causes, excluding still-births, recorded during the year 1903 was 443, which was practically the same as for 1902. This gives a rate of 11.72 per thousand for the year.

There has been no marked outbreak of infectious disease at any time during the year, even the opening of the schools in September failing to bring any marked increase in the number of cases recorded.

The school inspection has been continued as usual, three inspections being made during the year, one after each of the long vacations. Extra inspectors have been employed so that the work can be accomplished more rapidly. At the September inspection a child was found desquamating from scarlet fever. She was sent home and the room immediately disinfected. No further cases occurred which could be traced to this source.

The new smallpox hospital was completed early in the spring, but fortunately there has been no occasion to use it.

During the year 1903, 342 bottles of 1,500 antitoxin units each, supplied by the State Board of Health, were distributed to physicians.

A series of interesting cases of scarlet fever occurred in wards 5 and 6 during the early part of the year, an account of which seems worthy of record.

A number of cases were reported from the two wards in question at about the same time. There seemed to be no direct connection between them at first, but as they were investigated it appeared that they all took milk from the same man.

As soon as this fact was established an investigation was started which resulted in a visit to a milk farm in a neighboring community where nothing suspicious was found, but careful questioning brought out the information that a man employed there had left a few days before the inspector visited the place. This man was not ill, but his hands were tender and he was unable to milk. As nearly as could be determined from the description given the skin on his hands had been coming off, leaving tender new skin in its place. The man was supposed to have gone to Boston. His name and probable address were obtained and the aid of the Boston board of health invoked. The report was returned that he had spent only one night at the address given and had gone to a town in the centre of the State. Further attempts were made to find him, but all efforts failed and nothing more could be found out.

Judging, however, from the meagre facts discovered it is safe to say that this man had a mild attack of scarlet fever, and had continued at his work of milking during desquamation.

A curious fact in regard to the cases which developed was that they all occurred in patients who were in the habit of drinking milk raw. Babies and young children whose milk was pasteurized, or treated in a similar manner before being used, escaped.

Palmer.

During the summer the board had a canvass made to determine who had or had not entered the sewers in the several streets through which sewers passed. Notices were sent those whose dwellings were not connected, requiring them to do so in accordance with a vote passed by the town some time since, and in each case the order was immediately complied with or arrangements made to do so in the near future.

Few complaints of nuisances have been made and these were speedily and easily adjusted.

Pittsfield.

There are no laws which the public comply with so reluctantly as the laws for the preservation of health and the prevention of disease; consequently, the powers conferred on boards of health are often arbitrary, and in the exercise of such powers the freedom of the individual must necessarily be restricted, and it is just that individual rights should yield to the higher demand of public safety. Communities which have most carefully protected themselves and have most rigidly enforced the observance of health laws have enjoyed the greatest immunity from the ravages of pestilence. Following out this principle this board has rigidly enforced the laws and regulations pertaining to contagious diseases, with the result, as the facts seem to prove, that there have been the least number of contagious diseases during the past year than in any previous year since we became a city.

Plymouth.

Each year, with its added number of pupils in the public schools, urges more insistently the necessity for efficient medical inspection. Children in attendance at the public schools are constantly developing diseases which are sown broadcast among their companions because the unskilled eye of the teacher cannot detect the signs of danger until the harm is done. Not only is this true of acute contagious diseases, where the harm is quickly done, but of those insidious chronic diseases which find so prolific a field in the fertile soil of the school-room. At present any pupil whose physical condition is questioned by the teacher is referred to the chairman of this board, and if sufficient evidence is found to warrant it, the pupil is sent home and not allowed to return without a certificate of health. This is well enough as far as it goes, but it is a makeshift at best, practically leaving the medical inspection of the schools to the teachers, a task for which they are not paid. There should be a physician or physicians appointed, whose duty it should be to visit the schools at regularly stated intervals, noting any indications of disease among the pupils, and immediately removing any with suspicious symptoms. It should also be his duty to advise and direct the teacher wherever the health of the pupils is concerned, and he should inform the parents in all cases where, in his judgment, the pupils need any sort of medical assistance.

Quincy.

We expect at an early date to have the public protected against further exposure to the danger of sewage pollution of ice.

There has been a marked decrease in the number of infectious diseases reported to our board this year over last, as shown by the total of 241 against 458 in 1902. The most important check to the spread of contagion in diseases among children lays in the strict enforcement of the rules of quarantine, and the school is the most common ground of contagion.

Salem.

Salem is as yet without a proper hospital for contagious diseases as contemplated by statute law. The board have this winter, through the kindness of the committee on public property, been able to establish temporary quarters at the Potter farm, Ward 6. At the present time there are 3 patients in the old farm-house there, all doing well and strongly emphasizing the importance of the question, as called for years ago by the State.

The board very strongly recommend that public sanitaries for both sexes be constructed near the centre of the city. They feel this should be done for the health and convenience of our own citizens, as well as the many visitors, especially during the summer months.

Somerville.

Fifty-one cases of glanders have been reported during the year. Prompt action was taken in every case, and 49 of the horses were killed, 2 being released from quarantine by order of the Cattle Commissioners.

Number of houses placarded, ...	354
Premises disinfected by agent, ...	438

It will be seen by the foregoing figures that, in addition to the 354 premises infected with scarlet fever or diphtheria, 84 other premises were disinfected. This work was done at the request of attending physicians, whose patients, in nearly all cases, had been ill with consumption, typhoid fever or cancer. It has become the general practice among physicians to ask that rooms which have been occupied by persons suffering from consumption or cancer be disinfected.

Springfield.

The common carriers of infection, outside of persons and articles known to be infected, are water and milk. Great care and expense are indispensable in securing safe and wholesome supplies of these necessities of life. The water supply of this city during the summer months is often extremely disagreeable to both taste and smell, and urgent, immediate action to furnish a wholesome drinking water at this time is a crying need of this municipality. Much time and thought have been and are being put upon this question, and an early solution of the problem is earnestly hoped for. There can be no question but that the cause of the wholesale resort of the people to the use of well and spring waters during the summer is to be found in the fact that the city water is neither palatable nor wholesome at this time.

In October the board asked advice of the State Board of Health relative to certain public springs in use. In November a reply was received, and their recommendation that the use of certain springs be discontinued was promptly carried out, resulting in the closure of the following: five springs in Forest Park, Benton Park Spring, Wesson Spring, at the corner of Stockbridge and Willow streets. Several other springs on private ground used by the public were also analyzed, found to be polluted, and the owners properly notified.

Free vaccination has been offered as usual every Saturday morning at the board of health office.

The isolation hospital has proved invaluable to many people who have needed its services the past year. No other hospital was open to them, while the inconvenience and expense attached to caring for contagious cases at home often cause much loss of money, work and school time.

Wakefield.

The number of contagious diseases the past year indicates that our town has had a remarkably healthy period, there being only 34 cases against 226 the previous year.

Waltham.

The school inspectors were requested by the board to make monthly reports and blank forms were furnished them for this purpose.

Total number of children examined, ...	663
Total number of children sent home, ...	78

During the year a general inspection of the sources of our milk supply has been made. Every cow stable in the city was visited at least once during the year. All places where milk is stored and all utensils used in the work of drawing and storing such milk were examined. Sources of water supply for dairy herds and for washing milk cans, etc., were inspected, with a view to discover any pollution which might affect the milk.

Ware.

It is our intention to issue certain appropriate information in printed form from time to time to those suffering with tuberculosis and also to those who may be exposed to it. In this way, with the co-operation of the physicians, we hope to educate the people to the danger of the disease, the way in which it may be contracted, and the methods to be pursued in preventing it.

Watertown.

The town has been free from contagious diseases, which is due in no small measure to the system of school inspection, which is an effectual means of promptly detecting contagious diseases and thereby preventing an outspread of same.

Westfield.

The Keep Hospital, for the treatment of contagious diseases, was opened Feb. 28, 1903, and has proven a great blessing to the community. Nearly half our diphtheria patients have been treated there, and without a single exception words of praise for the hospital and its management have been given by the patients and their friends. At one time we had 4 diphtheria patients there from one family.

Immediate action in each case, and isolating the patient, stops the disease from spreading through the entire family or neighborhood.

We offer the following recommendations for consideration at our next town meeting: —

mainder of the time at Williamstown. These two cases have apparently no common origin with the other 11, all of whom are either students at the college or employed in connection with it. Of these cases, 1 went to bed on November 1, 1 on the 5th, 2 on the 6th, 3 on the 8th, and 3 on the 10th, since which time no new cases have developed. These cases were all young adults, with but one exception, this case being a boy nine years old, whose father was the cook at one of the fraternity societies.

The water supply of the college is obtained from the town's public supply, and although both reservoirs have been cleaned during the past season there are no indications of the water being the source of disease, for no cases have appeared among the other residents of the town, which constitute the greater part of the population.

The milk supply of these patients was obtained from two different sources, but from information obtained there is no reason to believe that the milk is the source of infection, both dealers delivering milk among other residents of the town.

Raw oysters had been eaten on but one occasion and only at one fraternity house.

The celery used at the fraternity houses was also from a common supply used about the town.

The cream supply for the college and for the residents of the town who use this article of food is obtained from the North Adams Creamery Company, two grades being in common use. The first is known as "heavy" cream, consisting of 40 per cent. cream; the other, "light" cream, consisting of equal parts of heavy cream and milk.

At Reuter's dining-room, where about 50 students board, and at two of the fraternity houses, the light cream is used exclusively, and among these people no cases of the disease have appeared. At three fraternity houses, where the heavy cream is used exclusively, 8 students are ill with the disease, and the father of the nine-year-old boy above mentioned is the cook at one of these houses. The tenth case was a young woman 21 years of age, a servant at one of the professors' houses, who was very intimate with the family of the cook at one of these three fraternity houses, and it was her custom to spend most of her leisure time with this family. The eleventh case was a student who, although he had not lived at one of these three fraternity houses, was very intimate with one of the students who was taken ill with the disease on November 1.

Of the 17 cases at North Adams, the records of which have been accurately kept by the board of health, 7 of them are known to have had access to the heavy cream similar to that supplied at Williamstown. Concerning the other 10, it is not possible to find any common source of infection.

The cream is obtained primarily from Hoosick, N. Y., it coming in two forty-quart cans daily by express to the North Adams Milk Company's depot in the afternoon. This supply is immediately put into a large, water-tight box, the cans being almost submerged in ice water, and it is allowed to stay in this receptacle until early the next morning. The cream is delivered by eight different routes in North Adams in connection with the milk supply delivered by the same company, it being estimated that one-half of the population of the city is supplied from this source. Another team carries a supply of milk, butter and both grades of cream

to Williamstown, where they are delivered among both college and town's people, but the heavy cream is supplied exclusively to the three fraternity houses. It is customary for the driver of this route to take with him ten quarts of heavy cream daily and return what is uncalled for — an amount varying from two to seven quarts — to the milk depot. This is kept in the ice-water tank previously mentioned, to be used as a source for special orders which almost daily come from different parts of the city.

Although suspicions point to the infection of the heavy cream carried to Williamstown and the subsequent delivery of what was brought back to North Adams as the probable cause of the disease, it is not possible to state the exact source of infection. The infection did not, evidently, exist in the cream as it was brought to North Adams from the dairy at Hoosick, for, if that condition was present, the lighter cream would also have been infected and some of those using it would have been taken ill with the disease; neither did it, apparently, exist in the cream first delivered at North Adams by the eight regular routes in the city, for, if this condition existed, more cases would have developed at North Adams, on account of the much greater amount of cream used in the city.

The conditions for handling milk and cream at the creamery, observed on December 4, seemed to be adequate and all utensils used were steam sterilized daily. No history of any person connected with the milk business, either at the depot or among the drivers of the teams, could be learned, and the time of infection seems so far back at present that with the information at hand it cannot be stated just how the infection was introduced.

Concerning the 7 cases in North Adams, it may be inferred that infection probably took place through the can of cream which had been returned from Williamstown, and which, apparently, was the source of the disease there. As additional evidence, one of the members of the Tufts College football team, which played at Williamstown on October 21, was taken ill with the disease on November 10. The football team stayed at the New Richmond Hotel, which is supplied with cream from this company. The incubation period points to his having contracted the disease while on this trip; but, on account of the fact that this team had played other games in other cities within this period, it cannot be stated as a positive fact that he did not receive the infection at some other time.

A further visit was made to Williamstown on December 21 to investigate 4 other cases which had been reported since the last visit. Upon investigation it was found that 2 of them had gone to bed ill at a time previous to November 16, coincident with the date upon which the other students ill with the disease went to bed. Another, although taken ill on November 15, went to his home at Troy, N. Y, and after observation by his attending physician it was decided that he did not have typhoid fever. The fourth went to bed on December 5 with symptoms simulating those of typhoid fever. He was in bed, however, only ten days, had entirely recovered, and was going to his home on December 21. The Widal reaction was negative in his case. From this investigation it has been ascertained that three fraternity houses, at which students boarded, were the ones affected by the disease. At the Zeta Psi house 21 students boarded, with 4 of them ill, and also the son of the house steward. At the Chi Psi house there were 22 boarders, of whom 3 and a servant were taken ill. At the Phi Delta Theta, accommo-

dating 18 students, 2 were taken ill. Of the 2 remaining cases 1 was a student living at the Sigma Phi house, who was in the habit of having a night lunch at Bemis's restaurant, where the heavy cream was used by him.

Of these 13 cases 6 of them had at times been away from Williamstown on short visits, but the remainder had not left the town since coming there at the beginning of the college term. Further investigation and inquiry was made at the milk depot and of the driver of the team going to Williamstown, but no definite information pointing to the exact source of infection of the cream could be ascertained, and it may be concluded that the source of infection was of a limited character and only of short duration. Of 20 cases using this heavy cream — all having been taken ill between the 3d and 17th of November — 2 proved fatal.

Winchester.

The general health of the town has been above the average, with a few more deaths than were recorded last year (the recorded mortality of which was remarkably low), but less than many preceding years. Contagious diseases, with the exception of measles, have been few and mild. The superintendent of schools and the teachers have been very strict in enforcing the filing of vaccination certificates before allowing pupils to be admitted to the public schools, and we feel that our system of fumigation is more thorough and effective than it is in many of our neighboring cities and towns.

In the matter of contagious diseases the board has ordered that where isolation could be readily obtained the wage earner should be allowed to continue at work, but where isolation could not be had the wage earner must board or live elsewhere or be quarantined. In all cases of tuberculosis the board has ordered that the attending physician report such cases to this board, and that all houses where deaths have occurred from the above cause must be fumigated by the board.

Worcester.

The number of deaths during the year was 2,069, a mortality of 16.25. This is an increase over that of last year, which was the lowest on record. This increase in the number of deaths is not due to any one cause but is divided among a number of the ordinary diseases. With the deaths at the two State insane institutions eliminated, the mortality rate is 15.13, a very low one.

In October 3 cases of typhoid fever were reported on the route of a milkman who lived in Shrewsbury. A visit was made to his home and 2 cases of the disease were found in his family. In November it was reported at this office that a milkman who lived in Holden was sick with typhoid fever. This place was visited, and the report was found to be correct. Immediate steps were taken in both of these cases to see that everything was disin-

Record of Visits made to Cities and Towns by Dr. Frank L. Morse, Medical Inspector, for the Purpose of investigating 137 Cases suspected of being Smallpox during 1903.

Case No.	City or Town.	Date.	Sex.	Age.	Character.	Successfully vaccinated.	Remarks.
1	Westford, . .	Jan. 2,	M.	25	Discrete, .	No, ...	Ill December 27. Eruption December 30. Eruption in vesicular stage.
2	Westford, . .	Jan. 2,	F.	22	Discrete, .	No, ...	Ill December 28. Eruption January 1 Eruption in papular stage.
3	Foxborough, .	Jan. 5,	M.	35	Discrete, .	No, ...	Came to Dipsomaniac Hospital from East Boston Dec. 1, 1903. Ill December 12, and eruption December 16. Diagnosis erroneously made of erythema papulosa. Over face and body to-day. A typical pigmentation of smallpox present. Discs in palms and soles.
4	Foxborough, .	Jan. 5,	M.	24	Confluent,	No, ...	Ill December 30. Eruption January 2. Eruption in vesicular stage. Orderly at hospital for case No. 3.
5	Foxborough, .	Jan. 5,	M.	20	Confluent,	No, ...	Ill January 2. Eruption January 5. Eruption in papular stage. Orderly at hospital for case No 3.
6	Foxborough, .	Jan. 5,	M.	58	Confluent,	No, ...	Ill January 2 Eruption to-day in papular stage. Patient at hospital with No. 3.
7	Foxborough, .	Jan. 5,	M.	43	Discrete, .	No, ...	Ill January 2. Eruption to-day in papular stage. Patient at hospital with No. 3.
8	Rockport, . .	Jan. 5,	F.	22	Discrete, .	Infancy, ...	Ill December 27. Eruption January 1. Eruption in pustular stage.
9	Rockport, . .	Jan. 5,	M.	1½	Discrete, .	No, ...	Ill in early part of December. Disease unrecognized.
10	Methuen, . .	Jan. 7,	M.	42	Discrete, .	Infancy, ...	Ill December 15. Eruption December 18. Remains of eruption present on body. Disease unrecognized.
11	Methuen, . .	Jan. 7,	F.	36	Confluent,	No, ...	Ill December 29. Eruption January 3. Eruption in vesicular stage. Hemorrhagic in places.
12	Westborough, .	Jan. 8,	M.	36	-	Infancy, ...	Diagnosis, measles.
13	Fitchburg, . .	Jan. 8,	F.	47	Confluent,	Infancy, ...	Came here from Boston January 4. Ill the same day. Eruption January 7. Eruption in papular stage Patient at Burbank Hospital.
14	Lynnfield, . .	Jan. 9,	M.	29	-	Infancy, ...	Diagnosis, measles.
15	Lynn, . . .	Jan. 13,	M.	3 months.	-	- -	Diagnosis, syphilis.
16	Lynn, . . .	Jan. 13,	F.	21	-	No, ...	Diagnosis, chicken pox.
17	Lynn, . . .	Jan. 13,	F.	27	Discrete, .	Infancy, ...	Ill January 9. Eruption January 11. Eruption in papular stage.
18	Watertown, .	Jan. 13,	F.	7	-	One year ago, . . .	Diagnosis, chicken pox.
19	Wareham, . .	Jan. 14,	M.	47	-	Infancy, ...	Diagnosis, measles.

20	Marblehead, .	Jan. 18,	M.	45	Discrete, .	Infancy,	Ill January 9. Eruption January 14. Eruption in vesicular stage.
21	Lynn, .	Jan. 19,	F.	16	Confluent,	No,.	Ill January 10. Eruption January 14. Eruption in pustular stage.
22	Dedham,	Jan 22,	F.	2	Confluent,	No,.	Ill January 16. Eruption January 18. Eruption in vesicular stage.
23	Dedham,	Jan. 22,	M.	33	Discrete, .	Infancy,	Exposed to unrecognized case Dec. 15, 1903. Ill December 28, and eruption December 29. Remains of smallpox eruption present over body.
24	Foxborough,	Jan. 22,	M.	40	Discrete, .	January 5,	Exposed January 3. Ill January 12. Eruption January 15. Drying up and crusts coming off.
25	Foxborough,	Jan. 22,	M.	42	Discrete, .	Infancy,	From South Boston to Dipsomaniac Hospital Nov. 26, 1903. Ill December 1, and remains of smallpox eruption present over body.
26	Foxborough,	Jan. 22,	M.	38	Discrete, .	Infancy,	Ill December 12 Eruption December 14. Remains of smallpox eruption over body.
27	Foxborough,	Jan. 22,	M.	34	Discrete, .	Infancy,	Ill December 12. Eruption December 14. Remains of smallpox eruption over body.
28	Foxborough,	Jan. 22,	M.	42	Discrete, .	Infancy,	Ill January 4. Eruption January 7. Remains of smallpox eruption over body.
29	Foxborough,	Jan. 22,	M.	30	Discrete, .	Infancy,	Ill December 21. Eruption December 24. Remains of smallpox eruption over body.
30	Haverhill, .	Jan. 23,	F.	39	Confluent,	No,.	Ill January 15. Eruption January 18. Eruption in vesicular stage.
31	Haverhill, .	Jan. 23,	M.	8 months.	Discrete, .	No,.	Ill January 2 and called chicken pox. Remains of smallpox eruption present over body infecting case No. 30.
32	Brockton, .	Jan. 25,	F.	30	-	Infancy,	Diagnosis, erythema multiforme.
33	Bradford, .	Jan. 25,	F.	16	-	Seven years ago,	Diagnosis, measles.
34	Methuen, .	Jan. 26,	M.	45	Discrete, .	Infancy,	Exposed January 11 to case No. 11. Ill January 22. Eruption January 25. Eruption in papular stage.
35	Haverhill, .	Jan. 27,	F.	22	Discrete, .	Infancy,	Eruption with no constitutional disturbance on January 23. Eruption in pustular stage.
36	Natick, .	Jan. 30,	F.	34	Discrete, .	Infancy,	Ill January 19. Eruption January 24. Eruption in pustular stage.
37	Natick, .	Jan. 30,	M.	33	Discrete, .	Infancy,	Ill December 29. Eruption December 31. Remains of smallpox eruption present on body. Disease unrecognized.
38	Methuen, .	Jan. 30,	F.	25	-	Infancy,	Diagnosis, measles.
39	Wakefield, .	Feb. 3,	M.	1	-	No,.	Diagnosis, chicken pox.
40-43	Salem, .	Feb. 5,	M., F.	6-9	-	Three no, one yes,	Diagnosis, chicken pox.
44	Lynn, .	Feb. 6,	F.	32	-	Infancy,	Diagnosis, chicken pox.
45	Lynn, .	Feb. 6,	F.	14	-	One year ago,	Diagnosis, chicken pox.
46	Lynn, .	Feb. 9,	M.	34	Discrete, .	No,	Ill February 3. Eruption February 7. Eruption in vesicular stage.

Record of Visits made to Cities and Towns by Dr. Frank L. Morse, Medical Inspector, for the Purpose of investigating 137 Cases suspected of being Smallpox during 1903 — Continued.

Case No.	City or Town.	Date.	Sex.	Age.	Character.	Successfully vaccinated.	Remarks.
47	Scituate,	Feb. 11,	F.	20	Discrete,	Two weeks ago,	Ill February 7. Eruption February 10. Eruption in papular stage.
48	Northbridge,	Feb. 12,	M.	21	Discrete,	No,	Exposed to unrecognized case January 18. Ill January 31. Eruption February 2 Eruption in crust stage.
49	North Uxbridge,	Feb. 12,	F.	48	Discrete,	No,	Ill January 15. Eruption January 19. Remains of smallpox eruption present over body.
50	Medford,	Feb. 15,	F.	23	-	Eight years ago,	Diagnosis, chicken pox.
51	Lynn,	Feb. 15,	F.	6	-	January 28,	Diagnosis, urticaria.
52	Ipswich,	Feb. 24,	M.	23	Discrete,	Infancy,	Ill February 14. Eruption February 16. Eruption in pustular stage.
53	Ipswich,	Feb. 24,	M.	35	Discrete,	Infancy,	Ill February 14. Eruption February 16. Eruption in pustular stage.
54	Ipswich,	Feb. 24,	M.	19	Discrete,	Infancy,	Ill February 21. Eruption to-day in papular stage.
55	Mansfield,	Feb. 24,	M.	51	Discrete,	Infancy,	Ill February 16. Eruption February 20. Eruption in pustular stage.
56	Attleborough,	Feb. 24,	F.	23	Discrete,	Infancy,	Ill February 16. Eruption February 18. Eruption in pustular stage.
57	Ipswich,	Feb. 26,	F.	19	Discrete,	Infancy,	Ill February 20. Eruption in vesicular stage.
58	Methuen,	Feb. 27,	M.	14	-	Nine years ago,	Diagnosis, erythema multiforme.
59	Ipswich,	Mar. 6,	M.	21	-	Eight days ago,	Diagnosis, urticaria.
60	Ipswich,	Mar. 6,	M.	21	-	Infancy,	Vaccinated one week ago and a reinoculation over right scapula.
61	Arlington,	Mar. 8,	F.	23	-	Fifteen years ago,	Diagnosis, erythema.
62	Pigeon Cove,	Mar. 9,	F.	16	-	Eight years ago,	Diagnosis, chicken pox.
63	Pigeon Cove,	Mar. 9,	F.	7	-	Three years ago,	Diagnosis, chicken pox.
64	Leominster,	Mar. 11,	M.	20	-	Infancy,	Ill March 4. Eruption March 8. Eruption in pustular stage.
65	Hyannis,	Mar. 13,	M.	31	Discrete,	Infancy,	Ill January 15 with smallpox unrecognized.
66	Hyannis,	Mar. 13,	F.	25	Discrete,	Infancy,	Ill February 1 with smallpox unrecognized. Wife of case No. 65.
67	Hyannis,	Mar. 13,	F.	3	Discrete,	No,	Ill February 20 with smallpox unrecognized. Child of case No. 65.

Record of Visits made to Cities and Towns by Dr. Frank L. Morse, Medical Inspector, for the Purpose of investigating 137 Cases suspected of being Smallpox during 1903 — Concluded.

Case No.	City or Town.	Date.	Sex.	Age.	Character.	Successfully vaccinated.	Remarks.
105	So. Framingham,	May 26,	M.	51	-	Infancy,	Diagnosis, chicken pox.
106	Leominster,	May 27,	M.	33	Discrete,	Fifteen years ago,	Ill May 6. Eruption May 8. Pigmentation of smallpox present over body. Disease unrecognized.
107	Leominster,	May 27,	M.	37	Discrete,	Twenty-five years ago,	Ill May 23. Eruption May 26. Eruption in papular stage. Infected by case No. 106.
108	Northborough,	May 29,	M.	47	-	-	Diagnosis, glanders.
109	Arlington,	June 7,	M.	5	-	One year ago,	Diagnosis, chicken pox.
110	Ipswich,	June 11,	F.	22	-	Infancy,	Diagnosis, chicken pox.
111	Hyde Park,	June 29,	M.	27	-	Two years ago,	Diagnosis, measles.
112	Hull,	Aug. 4,	F.	18	-	Infancy,	Diagnosis, impetigo contagiosa.
113	Hull,	Aug. 4,	F.	20	-	Infancy,	Diagnosis, impetigo contagiosa.
114	Wareham,	Aug. 8,	F.	11	Discrete,	No,	Ill July 31. Eruption August 1. Eruption in pustular stage.
115	Wareham,	Aug. 8,	M.	40	Confluent,	No,	Ill July 31. Eruption August 3. Eruption in pustular stage.
116	Wareham,	Aug. 8,	M.	11	Discrete,	No,	Here from Valley Falls, R. I., July 6. Ill July 11. Remains of smallpox eruption present over body. Infected cases 114-115.
117	Bernardston,	Sept. 16,	F.	22	Discrete,	No,	Exposed to smallpox at East Holden, Me., August 31. Ill September 10. Eruption September 13. Eruption in vesicular stage.
118	Duxbury,	Oct. 4,	F.	25	-	Infancy,	Diagnosis, dermititis.
119	Salem,	Oct. 13,	M.	1½	-	No,	Diagnosis, chicken pox.
120	Amesbury,	Oct. 20,	M.	37	Discrete,	Infancy,	Ill at Bangor, Me., October 11. Came here October 19. Eruption in crust stage.
121	Northbridge,	Oct. 29,	F.	8	-	Two years ago,	Diagnosis, chicken pox.
122	Northbridge,	Oct. 29,	F.	6	-	Two years ago,	Diagnosis, chicken pox.
123	Northbridge,	Oct. 29,	F.	6	-	Two years ago,	Diagnosis, chicken pox.
124	Northbridge,	Oct. 29,	F.	5	-	Two years ago,	Diagnosis, chicken pox and diphtheria.
125	Northbridge,	Oct. 29,	F.	3	-	Two years ago,	Diagnosis, diphtheria.

126	Haverhill, . .	Nov. 6,	F.	19	Discrete, .	No,.	Ill October 28. Eruption October 29. Eruption in pustular stage.
127	Lawrence, . .	Nov. 12,	F.	18	Discrete, .	No,.	Ill November 4. Eruption November 7. Eruption in pustular stage.
128	Lawrence, . .	Nov. 16,	M.	39	-	Thirteen years ago, . .	Diagnosis, chicken pox.
129	Haverhill, . .	Nov. 18,	M.	1	-	No,.	Diagnosis, chicken pox.
130	Salisbury, . .	Nov. 20,	M.	19	-	No,.	Diagnosis, chicken pox.
131	Leominster, . .	Dec. 1,	F.	44	Discrete, .	No,.	Ill November 10 with smallpox unrecognized. Remains of eruption present over body.
132	Leominster, . .	Dec. 1,	F.	32	Discrete, .	No,.	Ill November 23. Eruption November 25. Eruption in pustular stage.
133	Hudson, . .	Dec. 2,	M.	7 months.	Discrete, .	No,.	Ill November 21. Eruption November 23. Eruption in pustular stage.
134	Malden, . .	Dec. 11,	M.	18	-	Thirteen years ago, . .	Diagnosis, chicken pox.
135	Southbridge, .	Dec. 19,	M.	6	-	One and a half years ago, .	Diagnosis, chicken pox.
136	Brockton, . .	Dec. 23,	F.	29	Discrete, .	Infancy, ...	Ill December 15. Eruption December 19. Eruption in pustular stage.
137	Lawrence, . .	Dec. 26,	M.	52	Discrete, .	Infancy, ...	Ill December 18. Eruption December 23. Eruption in pustular stage.

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NAME	DATE DUE